A SMALL AREA ANALYSIS OF MORTALITY INEQUALITIES IN SCOTLAND, 1980-2001

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A Small Area Analysis of Mortality Inequalities in Scotland, 1980-2001

A thesis submitted to the University of St Andrews
for the Degree of Doctor of Philosophy

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Abstract

This thesis examines the changing patterns of mortality in Scotland, with particular emphasis on whether there are widening mortality inequalities among small areas in Scotland. The annual number of deaths in Scotland has decreased steadily since the 1950s, yet mortality rates in Scotland are amongst the highest in Europe for many causes. Furthermore, mortality from some causes, such as suicide, has been increasing over time, particularly among young adults. Evidence suggests that inequalities in mortality have widened over time in Scotland, despite substantial investment in policies aimed at reducing inequalities. Therefore, it is important to seek geographical clues that might help explain what causes these high mortality rates.

The changing patterns in Scottish mortality between 1980 and 2001 were examined for small areas, created by the author, known as Consistent Areas Through Time (CATTs). These areas have the same boundaries for each census, so that direct comparisons over time are possible. In this study, CATTs have been used to investigate three aspects of the mortality gap in Scotland. First, the widening mortality gaps between 1980-1982 and 1999-2001 are examined for the total population and for premature mortality (<65 years). Second, the influence that geographic scale and deprivation have on the relationship between population change and premature mortality are assessed. Third, suicide inequalities are examined for the younger (15-44 years), older (45+) and total population, using mortality ratios and statistical modelling.

The research found that inequalities in premature mortality (<65) have widened for all causes of death studied, particularly for suicide. The negative association between mortality and population change was affected by geographic scale, but this relationship could not be fully explained by deprivation. Small area analyses found that the Highlands and Islands had higher suicide rates than elsewhere in Scotland for males, but not females, when social variables were controlled for.

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Glossary

Term	*Definition*
CAS	Census Area Statistics
CATTS	Consistent Areas Through Time
Consistent SMRs	Mortality ratios standardised to a common geography and a common population base. e.g. 2001 quintiles, 2001 observed deaths, 1981 expected death rate
CPD	Central Postcode Directory
DETR	Department of Environment, Transport and Regions
EDs	1981 Census Enumeration Districts in Scotland
ESRI	Environmental Science Research Institute
GIS	Geographical Information System
GROS	General Register Office for Scotland
HEBS	Health Education Board for Scotland (now NHS Health Scotland)
ICD-9	The International Classification of Diseases (9^{th} Revision), developed by the World Health Organisation
ICD-10	The International Classification of Diseases and Health Related Problems (10^{th} Revision), developed by the World Health Organisation
LS	Longitudinal Study for England and Wales
MAUP	Modifiable Areal Unit Problem
NISRA	Northern Ireland Statistics and Research Agency
OAs	1991 & 2001 Census Output Areas in Scotland 2001 Output Areas for England and Wales
Older Population	Population aged 45 years +
ONS	Office of National Statistics
OPCS	Office for Census and Population Statistics
Period Specific SMRs	Mortality ratios calculated using the observed and expected values from the same period
PAF	Postcode Address File
PCOA	Postcode to Output Area lookup table
PHIS	Public Health Institute in Scotland (Now NHS Health Scotland)

Premature mortality	Deaths among the population aged below 65 years
Quintile	Category containing 1/5 of total population
Ratio Change	Relative Change in inequality between 1981 and 2001, calculated by dividing inequality ratios for 2001 by 1981
SIP	Social Inclusion Partnership
SMRs	Standardised Mortality Ratios
ST	Standard Tables (2001 Census)
WHO	World Health Organisation
Younger Population	Population aged 15-44 years

1. Introduction

Mortality rates in Scotland are the highest in the United Kingdom and Western Europe for some causes of death. For example, the death rate for mortality from all causes was 11.3 per 100,000 in Scotland for 2001; the highest in the European Union, and just 0.1 per 100,000 lower than the death rate for Romania in 2000 (GROS 2001a). Within Scotland, mortality rates vary by age, cause of death, and geography. There were 9 Council Areas that had an age-sex standardised mortality rate higher than the Scottish average in 2001, with the Glasgow City Council Area reporting the highest rate of 13.8 per 100,000. In contrast, East Dumbartonshire reported the lowest mortality rate, at 9.1 per 100,000 (GROS 2001a).

There is also evidence that inequalities exist between the least deprived and most deprived areas in Scotland. Carstairs and Morris (1991) constructed an index of deprivation using data from the 1981 census, and showed that mortality from all causes and for all ages were 1.34 times higher in the most deprived areas. Furthermore, the inequalities increased to 1.75 for mortality below 65 years. McLoone and Boddy (1994) used the same index derived from the 1991 census to analyse mortality data from 1990-1992 and reported a gap of 1.62 between the least deprived and most deprived categories.

In a wider context, Shaw *et al.* (1999) used a sample of parliamentary constituencies in the United Kingdom with the 'best health million' and 'worst health million'. The standardised mortality ratios (SMRs) in the 'worst health' areas increased from 155 in 1981-1985 to 178 in 1991-1995, while the 'best health' areas decreased from 76 to 68 over the same period. Thus, the inequalities widened from 2.04 in the 1980s to 2.62 in the 1990s. None of the 72 Scottish parliamentary constituencies appeared in the 'best health million', however, nine of the 15 constituencies comprising the worst health million were located in and around Glasgow City. Of the nine Scottish parliamentary constituencies, premature mortality (0-64 years) among the total population was highest in the Glasgow Shettleston constituency, and increased from 184 in 1981-1985 to 234 in 1991-1995. With an SMR of 156, the Glasgow Kelvin constituency had the lowest mortality of the nine Scottish parliamentary constituencies in 1981-1985, which increased to 158 in 1991-1995.

The majority of studies investigating health inequalities have been undertaken using relatively large areas, such as Countries, Health Boards, or Parliamentary Constituencies. While these scales provide robust results for areas that are readily identifiable to the layperson, they potentially mask smaller areas in which extreme conditions are experienced. The identification of such 'pockets' of high or low mortality might enable policy makers to redistribute health funding more effectively, or to develop specific healthcare interventions at a local scale.

To allow for a direct comparison of data through time, such as changes between 1981 and 2001, a consistent geography is required. A consistent geography is typically created by transforming data from two or more sources into a single common dataset. Many existing approaches to constructing a consistent geography apportion data to the target geography using population estimation techniques. However, these approaches inevitably incur error, as data are split according to some criteria (such as the proportion of an area that falls within the target geography), which may not reflect the underlying distribution of the population.

This Scottish study adds to a growing body of health inequalities literature in two ways. First, a consistent geography based on small areas is developed that facilitates the first reliable analyses of health and social data between 1981 and 2001 at the local scale. Second, the consistent geographical areas were used to examine the extent to which mortality differentials have widened (or narrowed) between 1981 and 2001 across all ages and for the population aged less than 65 years. Health inequalities are reported for all cause mortality, accidents, cancer, stroke, heart disease, respiratory disease, suicide, and all other causes combined.

1.1. Rationale

1.1.1. Trends in Mortality

Mortality declined throughout the developed, and parts of the developing, world during the 20th Century. In the first half of the 20th Century, the reductions were coincident with improvements in standards of living and economic development, and the subsequent reduction in infant mortality and deaths from infectious disease. However, as countries became more developed, life expectancy improved as more individuals survived childhood. During the second half of the 20^{th} Century living standards continued to improve, while the introduction of national health services, and technological developments in medical sciences ensured that mortality rates continued to decrease (WHO 1998).

As countries developed and life expectancy improved, the primary causes of death changed from infectious diseases such as tuberculosis, polio, and measles, to degenerative diseases such as heart disease and cancer. Omran (1971) defined this process the *epidemiological transition*, which had three 'ages'. First, the 'age of pestilence and famine' referred to societies in which infectious diseases were the primary cause of death and the health care system was rather primitive. Second, the 'age of receding pandemic' resulted from an improved health care system (and socio-economic standards), in which infectious diseases were less common, and individuals began to suffer from accident- or occupational-related mortality. The final age was 'the age of degenerative diseases', in which health care services were fully developed, morbidity rather than mortality was more common, and chronic diseases were the main causes of death.

Furthermore, Omran (1971) found that as a country experienced the epidemiologic transition, the prevalence of degenerative diseases followed a particular pattern. First, trauma-related deaths (e.g. accidents) were high following the introduction of a transportation economy. This was followed by non-insulin dependent diabetes dominated mortality as individuals gained weight, which led to peaks in cardiovascular disease and cancer.

While many developed countries have experienced the epidemiological transition, and thus an improved life expectancy at birth, infectious diseases continue to be the leading cause of death around the world. In 1997 there were approximately 50 million deaths worldwide, of which approximately 33% were due to infectious diseases, while circulatory diseases (i.e. heart disease and stroke) accounted for an additional 29% of all deaths. Cancers caused 12% of deaths and a further 6% of deaths were from respiratory diseases. The remaining 20% of global deaths were related to perinatal and neonatal causes (7%), maternal causes (1%), and other or unknown causes of death (12%) (WHO 1998).

The 1998 World Health Report (WHO 1998) reported that internationally, the average life expectancy at birth had increased from 48 in 1955 to 65 in 1995. However, the report also acknowledged that while health was improving, inequalities in life expectancy between and within countries existed. For example, WHO (1998) showed that there were more than five billion people living among 120 countries in which life expectancy at birth was above 60 years, a global health strategy outlined in the Health For All 2000 report. Meanwhile, over 50 million people were living in countries where life expectancy at birth was below 45 years, while life expectancy decreased in 16 countries between 1975 and 1995.

1.1.2. Trends in Health Inequalities

William Farr (1837, 1885, in Davey Smith *et al.* 2001a) first identified that some districts in England and Wales experienced better health than others. Indeed, mortality was highest in the 'great town districts' such as Liverpool, Manchester, London, Merthyr Tydfil, and Bristol, and mortality was lowest in Northumberland. Furthermore, Farr (1837,1885, in 2001a) recognised that mortality rates varied by age and sex, and demonstrated that the healthy districts could be used to determine the number of excess deaths occurring in the unhealthy districts. For example, the death rate among boys aged 0 to 5 years was 4,323 per 100,000 in the healthy districts, whereas in the unhealthy districts the death rate among boys in the same age group was 9,678. Thus, according to Farr, there was an excess of 5,355 deaths among boys aged between 0 and 5 years in the unhealthy districts.

The pioneering work by Farr (1837, 1885, in Davey Smith *et al.* 2001a) was complemented by the research of Chadwick (1842, 1965, in Davey Smith *et al.* 2001a), Rowntree (1901, 1971, in Davey Smith *et al.* 2001a), Booth (1902-3, in Davey Smith *et al.* 2001a), and Boyd Orr (1936, 1937, in Davey Smith *et al.* 2001a) who respectively associated sanitation, poverty, and nutrition with the socio-economic gradients in morbidity and/or mortality. The research of these pioneers ascertained that a social gradient in health existed. However, while measures such as better sanitation processes decreased the mortality rate during the 20th Century, mortality differentials between the least and most deprived sectors of the population persisted. It was not until 1980 when the Black Report (Townsend *et al.* 1992) was published that the full extent of inequalities between social classes in Britain was realised.

The Black Report explored differences in health and mortality by social class and found that inequalities between males in social class I (professional) and social class V (unskilled) had widened over time. For example, in 1949-1953 mortality among males aged between 35 and 44 years in social classes IV and V was 45% higher than among males in social classes I and II, and increased to 96% higher for the period 1970-1972. Furthermore, social class inequalities were apparent throughout the lifecourse, regardless of the health measure being considered. In 1971 males and females in social class V were two and a half times more likely to die prematurely than men and women in social class I.

In addition to the identification of inequalities, the Black Report made a number of recommendations to the Thatcher government that would help reduce inequalities. Sadly, these recommendations were ignored and as a result, Britain has continued to become a more socially polarised society. However, recent policies such as the abolition of tobacco advertising, and the current debate regarding the prohibition of tobacco smoking in public places, are borne from recommendations from the Black Report.

The Black Report gave four possible explanations for the existence of inequalities in Britain. First, they argued that the results were a statistical *artefact*, and that inequalities arose because the Registrar General's classification of social class by occupation was unreliable and therefore potentially inflated the health differences. However, later studies showed that when such problems were controlled for (e.g. Marmot and McDowall 1986, Goldblatt 1989), the pattern of inequalities remained.

Second, they suggested that health inequalities were the result of *natural selection*, whereby less healthy individuals move down the occupational scale, while more healthy individuals rise up the occupational scale. Selection has since been divided into *intra-generational* selection, which refers to movement from one occupational class to another during working age, while *inter-generational* selection refers to an individual moving to a different social class than his or her parents (Townsend *et al.* 1992). Recently, Manor *et al.* (2003) found that inter-generational health selection existed in the 1958 Birth cohort among males and females, but also identified intra-generational selection processes among males. However, Manor *et al.* (2003) suggested that the effect of health selection on the social gradient of health was marginal, and that selection did not wholly explain inequalities in health.

Third, *cultural/behavioural* factors were suggested as possible causes of inequalities. Under this hypothesis, it was suggested that there are differences in life-styles between classes, and that these differences are in turn related to health (Townsend *et al.* 1992). One might expect a strong relationship between lifestyle and health, but this is not always the case. For example, Drever and Whitehead (1997) showed a significant positive association between smoking and mortality, in which males and females in professional occupations had a lower smoking prevalence rate, and also had lower rate of mortality from lung cancer than unskilled manual workers. However, they also reported that males and females from professional occupations consumed more alcohol than other occupation groups. Similarly, Davey Smith *et al.* (1990) showed that after controlling for health behaviours, social gradients in mortality remained.

Fourth, the Black Report suggested that inequalities could be explained by *material factors,* which placed emphasis on the roles that economic and socio-structural factors had in the distribution of health and well-being. The authors of the Black Report believed that "it is in some form or forms of the 'materialist' approach that the best answer lies" (Townsend *et al.* 1992, page 114). Consequently, much of the research into health inequalities during the 1980s and early 1990s measured inequalities in terms of variations in material factors. Some researchers continued to use occupational social class in their analyses (e.g. Hunt *et al.* 1985; Marmot and McDowall 1986; Marmot *et al.* 1991), while others used variables from the 1981 (and later the 1991 and 2001) census to represent material deprivation (e.g. Townsend 1987; Carstairs and Morris 1991; Phillimore *et al.* 1994; Boyle *et al.* 2004a) in the examination of health inequalities.

Phillimore *et al.* 1994 used the Townsend (1987) Index of Deprivation to examine inequalities in mortality within the Northern Region of England between 1981 and 1991. They found that the mortality differential between the most deprived tenth and least deprived tenth of the population increased from 1.73 in 1981 to 1.95 in 1991. The widening gap was associated with a marginal decrease in mortality among the less deprived 10% of areas, whose standardised mortality ratio (SMR) reduced from 84 in 1981 to 81 in 1991, and the simultaneous increase in the SMR among the most deprived 10% of areas from 145 in 1981 to 158 in 1991. Furthermore, in absolute terms, mortality reduced among all of the least deprived areas between 1981 and 1991, but increased in some of the most deprived wards, particularly for men aged 15 to 44 years.

Drever and Whitehead (1997) showed that while life expectancy at birth for males in the UK increased from 69.2 years in 1972-1976 to 72.3 years in 1987-1991, life expectancy varied among the social classes. Males born in 1972-1976 whose fathers were in social class I or II (combined) had a life expectancy of 71.7 years, which increased to 74.9 years for babies born into the same social classes in 1987-1991. In contrast, male babies whose father was in a low social class (IV or V) could be expected to live for 67.8 years in 1972-1976, or for 69.7 years if they were born between 1987 and 1991. In addition, the life expectancy for males at birth increased in a linear fashion over time, but the life expectancy at birth among social classes IV and V decreased from 69.8 years in 1982-1986 to 69.7 in 1987-1991.

The Acheson Report (Independent Inquiry into Inequalities in Health 1998) effectively followed up the Black Report, and independently examined the evidence of health inequalities in Britain. The report commented on the widening inequalities in Britain with respect to children, education, employment, older people, people with disabilities and individuals living in poverty. More importantly, the Independent Inquiry into Inequalities in Health Report provided evidence that inequalities had continued to widen during the 1980s and 1990s. Their analysis resulted in 39 key recommendations to the Government, some of which were more general, while others were more specific to factors that were either directly or indirectly associated with poverty. Townsend (1999) suggested that of these 39 recommendations, recommendation number 3 – which related to the reduction of income inequalities and the improvement of living standards – was the core recommendation since it was directly associated with nine other recommendations in the report[1]. Townsend (1999) argued that the government urgently needed to make considerable improvements in the Benefit scheme, in order for vulnerable individuals such as young persons, lone parents and the elderly to experience a better lifestyle and thus reduce inequalities.

Deprivation indices were seen as an effective way to overcome problems associated with social class, such as the numerator/denominator bias that was inherent in the Black Report, and the ongoing discussion of the appropriateness of the class system. While the indices were useful tools in quantifying spatial variations in health by deprivation, their creation prompted discussion concerning the use of single (Folwell 1995) rather than composite (e.g. Carstairs and Morris 1991) indices; and also with respect to the transformation procedures used in the construction of composite indices (Gilthorpe 1995). In spite of these discussions, deprivation indices have continued to be useful proxies in the assessment of area-level health inequalities in the UK (e.g. Carstairs 1995; Haynes and Gale 2000; Geyer and Peter 2000; Kearns *et al.* 2000; DETR 2000; Aslanyan *et al.* 2003; Fone *et al.* 2003) and internationally (e.g. Crampton *et al.* 2000; Garcia-Gil *et al.* 2004; Singh *et al.* 2004).

Composite indices were useful tools for exploring material deprivation, but some academics sought alternative explanations for the widening inequalities between different factions of society. For example, during the 1990s, there was an increased interest in lifecourse epidemiology (e.g. Blane *et al.* 1996). Lifecourse epidemiology theory argues that childhood experiences influence characteristics in later life. Thus, the accumulation of adverse socio-economic circumstances and selection processes over one's life are important mechanisms, which may successively cause a downward spiral (van De Mheen *et al.* 1998). Lynch *et al.* (1997) examined the relationship between socio-economic status during childhood, and health and psychosocial behaviours during adulthood using data from Finland, and found that poor health in adulthood was more prevalent among men whose parents were also

[1] Recommendation numbers: 8 (employment) 13 (safe environment) 20 (access to food and a better diet) 21 (child poverty) 22 (women of child bearing age) 27 (material wellbeing of older people) 31 (minority groups) 35 (psychosocial health) 36 (disability).

poor.

As lifecourse epidemiology developed during the 1990s, so too did the debate relating to whether individual behaviour (*compositional)* or area characteristics (*contextual*) contributed most to health inequalities (MacIntyre *et al.* 1993). There have been many studies using a range of methodological approaches and data sources (e.g. Duncan *et al.* 1998; Mitchell *et al.* 2002; Phillips *et al.* 2004). Pickett and Pearl (2001) reviewed a comprehensive selection of papers surrounding the debate that used multi-level modelling techniques and found the results in the literature to be inconclusive. In the main, they found that contextual effects were less important than compositional factors, but were still significant. In addition, contextual effects have a stronger impact in studies of morbidity than in studies of mortality. Often, the context/composition debate has been assessed using samples of individual level data to adjust for health-related behaviours and using statistical approaches to test whether one or more contextual variables have a significant influence on a given health outcome, having adjusted for individual characteristics. For example, Jones and Duncan (1995) examined the relationship between respiratory function and ill health using a multilevel framework. Using data from the Health and Lifestyle Survey (Cox *et al.* 1993), they controlled for age, sex, height, smoking, dietary and employment status at the individual level, and two levels representing 'area'. First, at the ward level, they accounted for urban areas using a variable from the Health and Lifestyle Survey and deprivation, which was a composite of four census variables. Second, at the parliamentary constituency level they controlled for average household income. They concluded that there was an 'ecology' of chronic illness that remained once individual health-related behaviours had been controlled for. Thus, places that had the lowest income and had high levels of deprivation were susceptible to the highest levels of self-reported illness, heart problems and respiratory complaints.

More recently, Boyle *et al.* (2004b) used the Longitudinal Study to explore the (self reported) health and mortality of non-migrants in 1971 and 1991. They found that non-deprived non-migrants in areas that were in the least deprived quintiles in 1971 and 1991 had better health than non-migrants living in the most deprived areas for both periods. More importantly, they showed that changes in the relative deprivation of areas were related to health and mortality outcomes of individuals for morbidity and mortality, although the relationship was stronger for morbidity.

In addition to material factors such as housing conditions or accessibility to resources, there is also a wealth of literature regarding the association between income inequality and health. Wilkinson (1992) demonstrated a strong relationship between income distribution and health. When relative poverty was defined as the proportion of the population living on less than 50% of the national average disposable income, he demonstrated a correlation of –0.73 in the relation between relative poverty and life expectancy. Thus, countries that experienced more rapid reductions in poverty experienced an equally rapid increase in life expectancy. Four reasons were suggested with regard to this observation. First, countries with more egalitarian income distribution were more likely to have better public services that benefit health. Second, Wilkinson (1992) suggested that ethnic minority communities have poorer health than average and thus through lack of employment widen the income distribution. Third, reverse causality could explain the relationship between poverty and income distribution. He quickly refuted this because such an explanation would suggest that the cumulative contributions of economic factors such as unemployment and taxes would have little impact on the income distribution. Fourth, he suggested that mortality was directly affected by income distribution, and followed the assumption that health was responsive to variations in income among the poorer populations. His findings pointed to an association between health and the relative income distribution, rather than absolute wealth within countries.

The income-inequality and health relationship has been investigated extensively, but has yielded mixed conclusions. Kennedy *et al.* (1996) examined the relationship between income distribution and mortality in the United States using the Robin Hood Index and the Gini Coefficient, two regularly used measures of inequality. They found that there was little association between the Gini coefficient and mortality, but the Robin Hood index was positively associated with age-adjusted all cause mortality. When they controlled for poverty, each percentage increase in the Robin Hood index was associated with an increase of 21.68 deaths per 100,000. Thus, they reported that between-state variations in income inequality corresponded well with mortality and that policies that redistributed wealth could have a beneficial impact on health outcomes.

However, Lynch *et al.* (2004) examined the relationship between income inequality and infant mortality, as well as mortality from heart disease, stroke, suicide and homicide in the United States. They investigated national trends throughout the 20th century, and regional trends between 1978 and 2000. It was not possible to directly associate income inequality at the national level with continuously decreasing mortality rates. There was some evidence of a relationship between income inequalities and suicide among younger (15-44) adults, although the authors did suggest that the rise in suicides was not attributable to income alone. Their regional analyses exhibited a variable trend in the association between income inequality and mortality. For example, the States that experienced the highest increases in income inequalities also experienced the largest declines in mortality between 1978 and 2000.

Durkheim (1897) recognised that individuals that had more social connections were less likely to commit suicide than those individuals that had few friends or social networks. House *et al.* (1988) reviewed contemporary literature and reported that prospective studies regularly demonstrated higher mortality among individuals that had fewer social relationships. Wilkinson (1996) extended his previous research (1992) to state that wide income disparities resulted in increased stress, family disruption and frustration, which in turn heightened the rates of crime, mortality and homicide. Moreover, he suggested that more egalitarian societies had better social networks (also known as social cohesion and/or social capital), which also resulted in lower mortality rates. This notion has also attracted much attention in the literature. For example, Kawachi *et al.* (1997) used cause-specific mortality from 39 states in America and two measures of social capital (density of membership in voluntary groups per capita, and the level of social trust in each State) to examine the influences of social networks and income inequality on mortality. Lower levels of social trust were significantly associated with elevated rates of all cause mortality, cancer, infant mortality and stroke at the State level. The density of group membership was also significantly negatively correlated with mortality from all causes, heart disease, cancer, and stroke, in which an increase in membership density was associated with a decrease in mortality. The authors treated income inequality as a precursor to disinvestment of social capital, which elevated the risk of mortality.

In summary, this Section has demonstrated that for over 150 years academics have been alert to the fact that inequalities in health, and mortality in particular, exist between the least deprived and most deprived individuals or areas. Thus, in spite of a growing recognition that inequalities in health exist and are widening, policies and programmes developed to reduce inequalities have failed to curb the differential in mortality. Given these broad findings, our attention is now turned toward Scotland, on which this research focuses.

1.1.3. Mortality in Scotland

During the 20th Century, mortality in Scotland reduced steadily from approximately 82,296 deaths per annum in 1900 to 57,799 in 2001. During the same period, Scotland experienced an epidemiological transition in which the number of deaths from infectious diseases decreased from 10,971 (13.33%) in 1900 to 476 (0.82%) in 2000, while cancer mortality increased from 3,503 (4.26%) in 1900 to 15,255 (26.39%) in 2000 (GROS 2004a). However, while the number of deaths in Scotland has been decreasing steadily during the 20th Century, death rates for some health outcomes in Scotland are among the highest in the United Kingdom (Carstairs and Morris 1991; Griffiths and Fitzpatrick 2001a) and Western Europe (Leon *et al.* 2003). Griffiths and Fitzpatrick (2001a) reported a death rate of 1,141 per 100,000 for males in Scotland and 733 per 100,000 for females in Scotland, both of which were significantly higher than the UK averages of 976 and 624 per 100,000 respectively. In contrast, the mortality rate among males (866 per 100,000) and females (552 per 100,000) living in South West England were significantly lower than the UK average.

Deaths and death rates within Scotland vary by cause of death, gender, age, and Council Area (GROS 2002). For example, in 2001 there were 57,382 deaths registered in Scotland, of which 26% resulted from cancer and 21% were due to ischaemic heart disease. Standardised to the European population, death rates in Scotland from all cancers were considerably lower for females (282 per 100,000) than for males (319 per 100,000). However, the death rate from cerebrovascular disease (stroke) has been consistently lower for males than for females. In 2001, the death rate for stroke was 100 per 100,000 among males and was 159 per 100,000 for females. Of the 32 Council Areas across Scotland, 11 had mortality rates from all causes higher than the Scottish average in 2001. Furthermore, 8 of these 11 Council Areas were located in the west of Scotland, with Glasgow city experiencing the worst mortality in Scotland, some 22% higher than the Scottish average (GROS 2002).

McLoone (2003) examined trends in Scottish mortality between 1981 and 1999, and found that mortality from all causes among the population aged 15 years and over decreased from 1,543 per 100,000 to 1,257 per 100,000. However, closer investigation demonstrated that the reduction was not experienced by all ages. Mortality among the males aged 15-29 and 30-44 decreased slightly between 1981-1983 and 1989-1991, but had increased by 1997-1999. Mortality rates for heart disease, cancers, and stroke (combined) reduced for all periods and across all ages. In contrast, the rates for all other diseases combined increased between 1989-1991 and 1997-1999 among all age groups except males aged 75 years and older. Suicide was the major contributor to the increase among males aged 15-44 but increases were also substantial in mortality from drug-misuse and liver disease. Mortality from heart disease, stroke and cancers among males aged 60-74 decreased from 2,979 per 100,000 in 1981-1983 to 2,063 per 100,000 in 1997-1999. However, this favourable trend was overshadowed by an increase in mortality from chronic liver disease, which increased from 29.7 to 51.6 per 100,000.

Leon *et al.* (2003) reviewed the state of Scotland's health in relation to other countries in the European Union, and found that rates for accidents and external causes of death in Scotland were among the lowest in Western Europe. However, for other causes of death such as heart disease and all cancers, the rates in Scotland were the highest rates of the countries under investigation. Similarly, they found that males born in Scotland during 1995 could be expected to live more than 4 years less than men born in Sweden, while females were expected to live 5 years less than females born in France. Sweden and France were the countries with the highest life expectancy for males and females respectively.

1.1.4. Health Inequalities in Scotland

The analyses in the Black Report were derived from data for England and Wales, and only a few comparisons with Scotland were provided. However, Carstairs and Morris (1991) constructed an index of deprivation and compared inequalities between the most relatively deprived areas and the less relatively deprived areas in Scotland, at the postcode sector and Health Board level. Their composite index comprised of four standardised variables from the 1981 census, representing the proportions of males unemployed, people without access to a motor car, people living in crowded accommodation, and people in low occupational social classes (IV and V). The mortality ratio among males aged 0-64 years between 1980 and 1985 was 2.2 times higher in the most deprived areas than least deprived areas, while for females the Standardised Mortality Ratio (SMR) in the most deprived category was 2.0 times higher than the least deprived category.

McLoone and Boddy (1994) calculated the same index from the 1981 and 1991 censuses and assessed mortality differentials between the most and least deprived areas (postcode sectors) in Scotland. They demonstrated that inequalities between the most and least deprived categories had widened between 1981 and 1991; that inequalities varied between males and females; and also for different age groups. For example, inequalities for males aged 20-64 increased from 1.71 in 1980-1982 to 1.97 in 1990-1992, but for males aged 50-59 inequalities rose from 1.94 in 1980-1982 to 2.17 in 1990-1992.

Davey Smith *et al.* (1998a) examined the relationship between lifetime social class and mortality in a cohort of Scottish men. They found that participants who were in the manual social class as children (defined by their father's occupation); for their first job; and at the time of screening had a greater risk of mortality than participants who were from non-manual backgrounds during the same three life stages. In addition, they found that socio-economic conditions influenced some causes of death differently to others. Stroke and stomach cancer mortality were dependent on the social conditions experienced during childhood, while the social conditions during childhood and adult life influenced the risk of mortality from heart disease and respiratory diseases.

Shaw *et al.* (1999) examined the spatial distribution of social, political, economic and health inequalities at the parliamentary constituency level across Britain. They identified constituencies that contained the 'best health million' and the 'worst health million' residents in Britain. Premature mortality (<65) from all causes between 1991 and 1995 were 2.6 times more prevalent in the constituencies of the worst million, relative to the 'best million'. Furthermore, mortality was highest of all in Glasgow Shettleston, with an SMR of 234, 3.6 times higher than the mortality in the Wokingham, Woodspring, and Romsey constituencies, each of which reported the lowest SMR in Britain (65) for premature mortality. Inequalities between the best health million and the worst health million were also reported for a range of health and poverty measures, including the proportion of the population living: in poverty (relative ratio, 2.8); with an extremely low household income (12.2); with a limiting long-term illness (2.8).

More recently, Leyland (2004) found increasing district-level inequalities in premature mortality between 1979 and 1998 in Great Britain. During this period, absolute levels of mortality decreased in every region, but regional differences remained over time and continued to widen in all areas except in London, Wales and the South East. More importantly, the number of excess deaths was highest in Scotland, which increased from 25% in 1979 to 33% in 1998.

Scotland's unfavourable position results from a slower rate of reduction in mortality compared with European countries (Leon *et al.* 2003). Carstairs and Morris (1989) found that the majority of the differences in mortality between England and Wales and Scotland around the time of the 1981 census could be explained by their deprivation index. However, Hanlon *et al.* (2001) partially repeated the study by Carstairs and Morris (1989) and found that deprivation no longer accounted for the differences between England and Wales and Scotland. This observation was defined as the 'Scottish Effect'.

To allow for a direct comparison of data through time, such as changes between 1981 and 1991 (e.g. McLoone and Boddy 1994), a consistent geography is required. Each of the studies mentioned above that examine disparities in health were undertaken using relatively large geographical units, such as Health Boards (e.g.

Carstairs and Morris 1991) or regions (e.g. Griffiths and Fitzpatrick 2001a), because these geographic scales are relatively resilient to significant changes over time. In addition, the most detailed tabulations from the census are usually provided for larger areas (Norris and Mounsey 1983). Parliamentary constituencies (e.g. Shaw *et al.* 1999) have been used to assess changes in social patterns over time although the parliamentary constituencies are susceptible to minor and intermittent boundary changes.

In addition to the relative stability of these zones, the layperson can readily identify the names of Health Boards and parliamentary constituencies. On the other hand, the health status that is reported for a Health Board is effectively an average of the health experienced within a very large catchment, therefore potentially masking small areas of excessively high (or low) mortality.

1.2. Measuring Health Inequalities in Scotland

One of the problems associated with having many different theoretical perspectives of health inequalities is that there are also many alternate approaches to quantifying the extent of inequalities in a given population. Murray *et al.* (1999) contended that there was ambiguity between the definitions of 'health inequalities' and 'social group health differences'. Therefore, health inequalities was defined by Murray *et al.* (1999) as 'composite measures of the variation in health status across individuals in a population', while social group health differences were referred to as 'differences across subgroups of the population, which may be biological, social, economical or geographical' (p.537). Under these definitions, the majority of examples of health inequalities referred to in the previous section would be considered as 'social group health differences'.

Murray *et al.* (1999) also suggested that the ambiguity inherent in these two concepts in the literature has brought about a lack of standard definitions, measurement strategies and indicators. This lack of consistency impedes temporal comparisons within a country and also restricts the comparability of 'inequalities' between countries, which in turn limits the degree to which international inequalities in health can be examined. Even studies that do attempt to standardise data are problematic. For example, Kunst *et al.* (1998) obtained mortality data for men aged

30-44, 45-59 and 60-64 from 11 European countries and categorised the data into 7 common social classes based on occupation. They found that manual classes consistently had higher mortality than the non-manual classes, and that standardising social class still produced variability between countries. For example, Switzerland had the smallest ratio of 1.46 for mortality among males aged between 30 and 44, while Sweden reported mortality inequalities of 2.16. The authors commented on a number of problems associated with the study, including the availability of data for the same time periods; the classification of occupations; the numerator/denominator bias inherent in cross-sectional data; and confounding. Note also that the mortality inequalities in Sweden reported by Kunst *et al.* (1998) were in contrast to the favourable life expectancy at birth for Swedish males reported by Leon *et al.* (2003), and is a demonstration of how national level markers can conceal trends among particular age and sex groups.

In Scotland, the 'Measuring Health Inequalities Working Group' (2003) provided four different approaches to measuring inequalities among the population (social class and Carstairs index of deprivation; in terms of relative and absolute inequalities). They used mortality rates from heart disease among the population aged below 75 years to demonstrate the calculation of relative and absolute inequalities. *Relative* inequalities were calculated by dividing the mortality rate for the most deprived group by the mortality rate for the least deprived group. Thus, a ratio of less than 1.0 indicated that the mortality in the deprived area was lower than in the least deprived group. In contrast, *absolute* inequalities were measured by calculating the difference between the mortality rates in the most deprived and least deprived groups. The group recommended that inequalities in Scotland be measured in terms of relative inequalities.

Thus, it can be seen that there is a wealth of literature examining health inequalities. The material explanation of health inequalities that dominated the interpretation of inequalities in the 1980s and early 1990s was complemented by many other theoretical approaches. In part, this was due to the increased availability of social data sets (e.g. the Health and Lifestyle Survey), and technological developments (e.g. multilevel modelling). The Wilkinson hypothesis requires income data, which is not available from the decennial censuses in the United Kingdom. Similarly, the lifecourse epidemiological approach requires case histories of individuals to infer causal relationships.

In addition to consistent geographical areas, national coverage of social conditions from a consistent and reliable source is required for a better assessment of health inequalities in Scotland between 1980 and 2001. Therefore, this thesis employs data from the three most recent decennial censuses to explore health inequalities under the material deprivation framework. The Carstairs index of deprivation (Carstairs and Morris 1991) is used throughout the study as a marker for deprivation, since this index was originally designed for the Scottish population.

This study adds to the growing body of literature concerning health inequalities in a number of ways. First, the author has used an alternative approach to constructing a boundary file of consistent small areas through time in Scotland, which is arguably more robust than existing techniques and means that, for the first time, health and social data can be examined at a relatively local scale. Second, these small areas are used to examine inequalities in mortality across all ages, and for the population below 65 years of age, for deaths from all causes and for accidents, cancer, heart disease, respiratory disease, stroke, suicide, and all other deaths combined. Furthermore, the inequalities between the least deprived and most deprived areas in Scotland are examined using traditional and alternative techniques created by the author. Third, this study examines the extent to which geographic scale and deprivation influence the relationship between population change and mortality. Fourth, the changing geography of suicide inequalities is examined, in which clusters of suicide are identified using an inherently spatial approach, whereas much of the contemporary evidence for suicide clusters is anecdotal or based on conventional statistics.

In this study, a number of quantitative techniques are used to examine the changing patterns of Scottish mortality between 1980 and 2001. This study achieves the contributions to the health inequalities literature through four key research objectives:

1. *Develop a geographical boundary file to enable reliable analysis of census and mortality data between 1981, 1991 and 2001.*

   In order to analyse mortality and social patterns through time a reliable, consistent geography is required. The approach developed by the author is more robust than existing approaches, because no population estimation procedures are required.

2. *Examine the mortality differential between the least deprived and most deprived areas by age group (all ages and under 65 years) and gender for deaths from all causes, and deaths resulting from: accidents; stroke; cancers; heart disease; respiratory disease; suicide; and all other causes combined.*

   The General Register Office for Scotland regularly uses these causes of death to report mortality trends at the national level. In addition, premature mortality (<65 years) is examined because the causes of death studied could be prevented through medical intervention.

3. *Investigate the influences that geographic scale and deprivation have on the negative association between population change and mortality, for all causes and cause-specific mortality.*

   The relationship between population change and mortality has been examined in the literature, but to date the effects of geographic scale and the role of deprivation have not been examined to any great extent.

4. *Investigate the small area geography of suicide in Scotland, and the differences in suicides for males and females, and for the younger and older populations.*

Suicide was chosen because there is evidence from other countries that suicide is decreasing among older populations but increasing among younger adults. In addition, since the occurrence of suicide is relatively rare, it provides a suitable platform to demonstrate the application of small area analyses to examine health inequalities in Scotland.

1.3. Structure of the Thesis

This thesis begins by providing a more detailed review of recent trends in Scottish mortality in relation to countries in Western Europe, and the other constituent countries of the United Kingdom, before examining patterns of mortality within Scotland. The chapter concludes with a discussion of the policies that the Scottish Executive has implemented to help reduce inequalities in Scotland.

Chapter Three introduces the datasets and the main methods used throughout the thesis. In particular, the mortality and census data are discussed, as well as the construction of the deprivation indices and the formula used to measure health inequalities in Scotland. It should be noted that some specific methods are included in the relevant Chapter.

The first thesis objective, constructing relatively local consistent geographical areas for Scotland, is discussed in Chapter Four. After a review of the existing approaches for creating consistent geographical areas, an alternative method devised by the author, is used to construct a new digital boundary file, known as Consistent Areas Through Time (CATTs). The CATTs enable reliable comparisons between 1981, 1991 and 2001 to be made for the first time at a relatively local scale.

In Chapter Five, the CATTs are aggregated into population-weighted deprivation quintiles, to investigate the widening mortality gap in Scotland, and to examine the second thesis objective. Analyses are conducted for males and females separately and combined; based on mortality at all ages and for premature mortality, defined in this thesis as deaths occurring between 0 and 64 years of age (inclusive). The mortality gap is examined for deaths from all causes, as well as accidents, stroke, cancer, respiratory disease, heart disease, suicide, and all other causes combined.

Chapter Six examines the third objective of the thesis, and explores the roles of geographic scale and deprivation on the relationship between population change and premature mortality. The CATTs are aggregated to approximate Health Boards 2001 Council Areas, 1991 Districts and 2001 Parliamentary Constituencies, to explore the influence of geographic scale. Population-weighted deprivation quintiles derived from the 2001 Carstairs index of deprivation, are used to examine the extent to which deprivation explains the negative association between population change and mortality.

Chapter Seven investigates the final thesis objective, the changing geography of suicide in Scotland, and investigates whether there are different trends with regard to inequality between the younger and older populations. Furthermore, the CATTs are used as individual zones first to identify spatial clusters of suicide, and second to determine whether the social composition of CATTs can be used to predict the risk of suicide at a local scale.

Chapter Eight concludes the present study by summarising the main results in relation to the original thesis objectives. In addition, the potential impact of the results from this research on policies related to health and inequalities in Scotland are discussed. The limitations of the current study and opportunities for future research are followed by a summary of the key findings.

2. Mortality in Scotland

2.1. Introduction

This Chapter provides a detailed discussion of mortality and mortality differentials in Scotland. It builds on the discussion in the previous Chapter and establishes that Scotland's health is comparatively poor in relation to other European countries. Furthermore, this Chapter shows that the existing research concerned with health inequalities in Scotland is undertaken for relatively large geographic areas, which potentially masks local variation.

Although the annual number of deaths in Scotland declined steadily throughout the 20th Century, the declines in Scotland were not as rapid or substantial as other parts of the United Kingdom and Europe. Furthermore, Scotland experienced an epidemiological transition during the last 100 years, in which the prevalence of deaths due to infectious diseases diminished and deaths from chronic health problems such as cancer became prominent. First, this Chapter reviews the mortality trends in the European Union in relation to the United Kingdom, and wherever possible, Scotland. Second, Scotland's mortality experience is discussed in relation to other countries of the United Kingdom. Third, geographic variations in mortality in Scotland are reviewed before concluding the Chapter with a discussion of the policies that the Scottish Government, known as the Scottish Executive, has established in order to improve the health of Scotland.

2.2. Mortality in Scotland in Relation to European Countries

There have been relatively few studies that discuss the health of Scotland in an international context, as most studies consider the Scotland as part of the UK rather than as a separate entity. For example, Warnes (1999) examined European trends in cause-specific mortality rates among the population aged 60-64, 70-74 and 80-84, between 1960 and 1990. Mortality rates from all causes declined during each decade in the study, although the extent of the decrease differed by age group and sex. In 1960, the mortality rate from all causes for males in the UK aged 60-64 was 11%

higher than the European average (i.e. the average of the 16 countries examined), however, by 1990 the mortality rate among this group was just 4% higher than the European average. In contrast, the mortality rates among females from the UK aged between 60 and 64 years worsened over time. The rate for mortality from all causes was 6% higher than the European average and by 1990 the rate had increased to 30% higher than the European average.

Warnes (1999) also examined trends in mortality from specific causes for the UK in relation to Switzerland. In 1960, the occurrence of death among males from diabetes, cirrhosis, and accidents were lower in the UK relative to Switzerland, while cancers, cardiovascular disease, stroke, undefined and other causes were relatively higher in the UK. By 1990 the same trends were found, except that undefined causes among males aged 80-84 were relatively lower in the UK than in Switzerland. More importantly, however, was that although the rates of diabetes, cirrhosis, and other causes remained lower than in Switzerland, they had worsened over time. For example, for males aged 70-74, the differential between the UK and Switzerland for diabetes was 0.49 in 1960, but in 1990 the differential had closed to 0.83.

Similar patterns were reported for females, although the differential between the UK and Switzerland were notably higher for some causes than for males. For example, while cardiovascular disease rates in the UK increased from being 1.42 times higher than Switzerland in 1960 to 1.71 in 1990 for males aged between 60 and 64 years, cardiovascular disease inequalities increased from 1.19 in 1960 to 2.62 in 1990 for females in the same age group. In addition, the relative difference in stroke mortality among females aged 60-64 increased from 1.81 in 1960 to 2.84 in 1990, compared with an increase from 1.46 in 1960 to 1.79 in 1990 for males aged 60-64.

Nolte and McKee (2003) ranked the health of 19 countries from the Organisation for Economic Cooperation and Development (OECD) in terms of premature mortality (defined as death before 75 years of age), and disability adjusted life years (DALY). Age standardised death rates were calculated for 34 different health outcomes. The UK, of which Scotland was part due to data restrictions, worsened from 10th position in terms of DALY to 18th position based on death rates for amenable mortality, and fell to 19th position when ischaemic heart disease was incorporated into the death rates. The results by Nolte and McKee (2003) emphasised the problems associated with analyses that derive rank positions based on composite measures, such as the DALY, as they were shown to be sensitive to the concepts and definitions used in their construction.

Carstairs (1988) examined mortality differentials between Scotland and eleven European countries in addition to comparing Scotland with England and Wales. The differences between death rates were calculated for 1973-1975 and 1981-1983, for males and females aged 45-54, 55-64 and 65-74 for deaths from all causes, heart disease, all cancers and lung cancers. For each cause of death, Scotland's relatively poor health standing was emphasized. Finland had the highest mortality from all causes amongst males in the first period while Scotland was a close second. Over the decade under study, Finland showed a significant reduction in all cause mortality, while Scotland's improvement was much more moderate, making it the country with the highest mortality in 1981-83. For example, the death rates for males aged between 45 and 54 reduced by 27% over the decade in Finland, compared with a 14% reduction in Scotland. In terms of cause specific mortality, males in Scotland were consistently amongst the top three countries. For each cause of death, the rate for Scottish males decreased during the study, but the reductions were typically marginal or not as great as the countries with which they were compared.

Although the death rates for females were approximately 50% lower than for males, their mortality record was just as poor. Moreover, while the death rates for males were consistently the highest or second highest across all age groups and time periods, the rates decreased over time. In contrast, the death rate for all cancers and lung cancers increased for females aged 55-64 and 65-74. This older age group reported an increase of 91% in lung cancer, which was comparable to the increases reported for the same age group in the USA, Australia and Canada.

There have been very few studies that have compared the relative position of Scotland and other international countries since the work by Carstairs (1988). Those studies that do make international comparisons have typically been restricted to trends observed for the incidence and/or mortality from cancer. Despite many countries using the International Classification of Diseases and Related Health Problems to register deaths, the coding practises between countries are problematic (Levi *et al.* 1996). Nonetheless, Vercelli *et al.* (1998) compared trends in cancer incidence and mortality between 1978 and 1992 for males and females aged between 35 and 64, and those aged 65 years and older in Western Europe. Their data were derived from the European Cancer Incidence and Mortality (EUROCIM) database, which incorporates data from the cancer registries of Denmark, England and Wales, Finland, Ireland, The Netherlands, and Scotland (collectively referred to as 'Northern Europe'), Austria and France ('Central Europe') Italy, Portugal and Spain ('Southern Europe').

They found that cancer mortality in the younger age group was decreasing and that the death rates were similar for all countries. In contrast, the mortality rates for the older (65+) age group increased over time in Northern and Southern Europe, while the Central European countries exhibited marginal decreases. Vercelli *et al.* (1998) calculated the 'percentage mean difference' to describe the changes in incidence and mortality for each country, by age and gender. On average, cancer rates for younger males in Scotland decreased by 1.1% per annum, while the older population demonstrated an average increase of 0.7% per annum. Finland reported the biggest average annual reduction for younger men (-2.2%) and the annual increase was largest in Spain at 1.2%. The cancer trends for Scottish females were similar to males whereby the younger age group decreased (0.5%) and the rates amongst the older population increased (1.1%). It should be noted that for males and females in Scotland the percentage change was only statistically significant for the older age group. While the average percentage increases or decreases do not appear to be substantial, Scotland's rank position varied considerably between the age groups. In the younger age group (35-64), Scotland was ranked third[1] for males and fourth for females, which was equal with Finland and Italy. The favourable rankings for premature mortality were not paralleled in older age, however, where men were ranked seventh and females were ranked ninth.

[1] In this ranking, a value of 1 represented the biggest average decrease.

The EUROCIM database was also used by Botha *et al.* (2003) to examine the incidence and mortality trends of breast cancer in 16 European Countries: Czech Republic and Slovakia (Eastern Europe); Denmark, England and Wales, Estonia, Finland, Iceland, Norway, Scotland and Sweden (Northern Europe); Italy, Slovenia and Spain (Southern Europe); France, the Netherlands and Switzerland (Central Europe). They used age standardised incidence and mortality rates for females aged 35-49, 50-64 and 75-74 and found that incidence rates increased over time, except for the 35-49 age group in Scotland, Slovenia and among women aged 35-49 and 65-74 in Switzerland, for which no apparent increase was evident.

Botha *et al.* (2003) found that breast cancer mortality decreased in Sweden since the 1950s, whereas for all other countries the mortality rates had increased or remained constant until the mid 1980s. During the 1980s, six countries (England and Wales, Finland, Iceland, Netherlands, Scotland and Sweden) introduced screening programmes, and by the 1990s the mortality rate was stabilising in Finland, and decreasing for England and Wales, The Netherlands and Scotland for some or all of the age groups studied. They used the Estimated Annual Percentage Change (EAPC) to assess the time trends for the most recent decade that data were available for, and reported variation between these countries as well as within each age group for a particular country. For example, between the ages of 35 and 74, England and Wales exhibited an EAPC of -3.1%, compared with a -2.0 % average reduction in Scotland and a 1% reduction in The Netherlands. The EAPC for breast cancer mortality in females aged between 35 and 74 masked some considerable reductions found for different age groups. Iceland had an EAPC of –0.5% for all ages, which hid the EAPC of -4.9% for females between 35 and 44 years and the contrasting 5.0% increase found for females aged between 65 and 74 years. In Scotland, the EAPC for females aged 35 to 49 was –2.0%, the same as the EAPC reported for females between 35 and 74 years. However, the EAPC decreased with age, with Scottish females aged between 50 and 64 experiencing an EAPC of –1.8% and females aged between 65 and 74 reporting an EAPC of –1.4%. However, the behaviour of breast cancer is uncharacteristic, because unlike other forms of cancer, incidence and mortality maybe inversely associated with deprivation (e.g. Griffiths and Fitzpatrick 2001a).

Leon *et al.* (2003) used data obtained from the World Health Organisation for 17 countries from Western Europe and compared their mortality patterns with Scotland between 1950 and 1998. The report examined trends in all cause mortality, for infants (0-1) children (1-14), working age (15-74) and the elderly (75+). They also examined trends in working age mortality for a range of specific causes: cancers (oesophageal, lung, and breast); ischaemic heart disease; cerebrovascular disease (stroke); liver cirrhosis; external causes and suicides.

Table 2-1 shows that since the 1950s, all cause mortality reduced except among working age (15-74) males, which did not begin to decline until after 1975. Despite the decreasing death rates, Table 2-1 also shows a divergence from the Western European mean for females aged over 15 years of age, indicating that reductions in female mortality in Western Europe were much greater than those observed in Scotland. This is emphasized in the final two columns of Table 2-1, which lists the trends in Scotland's rank position relative to the other 16 countries that Leon *et al.* (2003) examined, with a rank position of '1' indicating the highest rates of mortality for a particular age group. Thus, Table 2-1 shows that the mortality rates of the Scottish working age population have been the worst in Western Europe since the late 1950s and late 1970s for females and males respectively.

Age Group	*Scottish Trend*		*Scotland Compared to Western European Mean*		*Scotland's Rank in Western Europe (1956-1995)*	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
0-1	Declined	Declined	Parallel	Parallel	Between 4th and 9th	Between 6th and 9th
1-14	Declined	Declined	Parallel	Parallel	Between 8th and 13th	Between 5th and 13th
15-74	Declined from 1975	Declined	Parallel	Diverged	1st since 1978	1st since 1958
75+	Declined	Declined	Parallel	Diverged after 1975	Between 3rd and 4th from 1965	Worsened to become 3rd during the 1990s

Table 2-1 Summary of Scottish all cause mortality trends in relation to 16 Western European countries, 1956-1995 (Source: Leon *et al.* 2003 p.37)

The poor health of the working population in Scotland prompted Leon *et al.* (2003) to examine trends in cause specific mortality between 1956 and 1995. For males and females, the death rates for oesophageal cancer were slightly higher than the Western European mean in the 1950s, and remained relatively steady until about 1970 when the rates increased to become the highest in Western Europe. The lung cancer death rates were the highest in Western Europe for females throughout the second half of the 20th Century, and rose consistently throughout the period. Similarly, males also had the worst lung cancer rates in Western Europe until 1980, when the death rates in Belgium became slightly higher than Scotland.

Botha *et al.* (2003) noted that the breast cancer patterns in Scotland were very similar to those in other parts of the UK, while Leon *et al.* (2003) showed that the rate for Scotland was constantly amongst the worst 4 in Western Europe between 1950 and 2000. Nevertheless, the breast cancer screening programmes appeared to be working, as the death rate for breast cancer in Scotland has shown a sharp decrease since the early 1990s. Consequently, breast cancer mortality demonstrated a convergence toward the Western European mean.

Working age females in Scotland also exhibited the worst death rates in Western Europe between 1950 and 2000 for ischaemic heart disease, while mortality for males fluctuated between 3rd and 1st position. For both sexes, rates of ischaemic heart disease have been steadily decreasing since 1980, but the rate of change has not been as rapid as the reductions experienced by the other Western European countries. In terms of stroke mortality, the trend for Scotland's males and females does look promising, as it has been decreasing since the 1950s. However, despite appearing distant from the Western European maximum, Scotland was regularly ranked 2nd behind Portugal for males and females, except between 1965 and 1970, when males were ranked third (Leon *et al.* 2003).

Mortality from cirrhosis of the liver has been increasing steadily for males and females the 1950s. Scotland has moved from 12th position to 10th in 1990-1995 for men, and from 10th to 7th for females. Sharp increases observed during the 1990s (for both males and females in Scotland) meant that by 2000 cirrhosis mortality was highest in Scotland for both sexes. These increases were contrasted with reductions in cirrhosis mortality in the other Western European countries (Leon *et al.* 2003).

External causes of death, such as road traffic accidents, and death from suicide were the only causes of death examined by Leon *et al.* (2003) where the rates for males were consistently below the Western European average. Between 1956 and 1995, the death rate for Scottish men from external causes was regularly ranked 12th in Western Europe, with the exceptions of 1970-1975 when it was ranked 14th. In addition, male deaths from external causes have been ranked 13th since 1990. A steady increase in suicides amongst Scottish males resulted in a convergence with the Western European mean. Until 1980, the death rate for male suicides in Scotland was only 12th out of the 17 countries surveyed. However, the rank position worsened to 10th position during the 1980s, but improved slightly to become the country with the 11th highest suicide rate in the 1990s.

Females exhibited very different trends than males for external causes of death and suicides. Until 1970, the female death rate fluctuated around the Western European mean, and was regularly ranked 9th. Since 1970 the death rate for external causes has fallen below the Western European mean and subsequently dropped to 10th position between 1990 and 1995. While male suicides have demonstrated a convergence toward the Western European mean, the suicide rates for females were parallel with the Western European mean, and have been steadily declining since the 1980s. Consequently, Scottish female suicide rates were ranked 10th highest in Western Europe until 1980, after which they have maintained 11th position.

This section has therefore highlighted Scotland's poor mortality record in comparison to other European countries. Scottish males and females consistently experienced the highest levels of mortality in Europe, for some causes of death, such as ischaemic heart disease. However, within Scotland, (negative) changes in health behaviours, such as increases in binge drinking and tobacco smoking (The Scottish Executive 2002a) have increased the mortality from other causes other causes of death (e.g. cirrhosis). Although the health of the Scottish population has been shown to be worse than other European countries, comparisons have not yet been made with the other countries within the United Kingdom – England, Wales and Northern Ireland. The following Section assesses Scotland's mortality trends in relation to these countries.

2.3. Mortality in Scotland in Relation to Other Countries of the United Kingdom

The Office for National Statistics (ONS) and its predecessor (The Office for Census and Population Statistics, OPCS) is responsible for the collection and dissemination of vital statistics, such as births, deaths, and marriages and also for reporting population trends in England and Wales. The General Register Office for Scotland (GROS) collects and disseminates these data within Scotland and therefore studies typically compare Scotland with England and Wales combined.

Hicks and Allen (1999) briefly compared trends in health between 1880 and 1997 for the UK. They showed that in 1880, 3% of deaths were recorded as cancers, while 7% of deaths were attributed to diseases of the circulatory system (stroke, heart attack etc). In contrast, these two causes of death accounted for 25% and 41% of deaths in the UK in 1997. Conversely, 33% of deaths in 1880 were due to infectious diseases, but by 1997 only 17% of deaths were due to infectious diseases. The large majority of deaths were categorised as 'other diseases' in 1880, possibly due to the lack of medical knowledge, but also included deaths due to 'old age'. A further observation made by Hicks and Allen (1999) was that between 1991 and 1995, 12% of the population died prematurely (aged below 60 years). In contrast, almost two thirds (63%) of deaths in the UK during 1880 were premature according to this definition.

The Black Report (Townsend *et al.* 1992) was influential in driving health inequalities research in the United Kingdom. The report emphasized the striking difference in mortality and morbidity between the proportion of the population belonging to Social Class I (professional) and Social Class V (unskilled). Townsend *et al.* (1992) found that mortality inequalities between economically active males from social class I and social class V were greater in 1959-63 and 1970-1972 than in 1949-1953. Increases in the mortality gap were shown to result from mortality in social classes III, IV and V either increasing or remaining stable, while mortality in social classes I and II reduced, particularly for males aged between 35 and 64. For example, when mortality ratios were calculated relative to social class I and II combined (SMR=100), the mortality ratios for men aged between 35 and 44 years in social class IV and V combined increased from 133 in 1949-53 to 164 in 1970-1972.

Although the Black Report (Townsend *et al.* 1992) elucidated the apparent health inequalities between occupational social classes, the authors of the Report were criticised for the methods they used to report inequalities. In particular, the social class variable used to classify the mortality data was derived from death certificates, which has been shown to be unreliable as the bereaved tend to 'sell up' the deceased's occupation (Carstairs and Morris 1991). In contrast, the social class variable used to classify the population was derived from the decennial censuses therefore introducing 'numerator/denominator' bias. The Longitudinal Study (LS) in England and Wales (Fox and Goldblatt 1982) was developed to examine trends in occupational mortality by social class, and consequently overcame the numerator/denominator bias.

Many of the results in the Black Report (Townsend *et al.* 1992) were derived results from the OPCS decennial mortality publications, and therefore regional variations that included Scotland were limited. Whitehead (1992) reviewed the literature regarding health inequalities in Britain and updated the conclusions of the Black Report to include the 1980s; accounted for the numerator/denominator bias; and incorporate observations for Scotland into the findings. The results highlighted the significant differences between the health of England and Wales and Scotland. For example, Whitehead (1992) showed that the mortality rate for Scottish men aged between 20 and 64 was 6.92 per 1,000 based on mortality data from 1979-80 and 1982-1983, compared with 5.43 per 1,000 for men in England and Wales. Moreover, in an analysis of British regions the mortality rates for males during the same period were highest for Central Clydesdale (7.86 per 1,000) and Strathclyde (7.14 per 1,000). In contrast, East Anglia had the lowest mortality rate of 4.37 per 1,000.

Carstairs (1988) used data from the 1984 General Household Survey (for England and Wales) and the Scottish Health Survey for 1984 to compare the health and lifestyles of men and women in Scotland with those in Great Britain. The analysis highlighted the generally poor health behaviours of the Scottish population. For example, 15% of males and 13% of females in Scotland reported fair to poor respiratory function, compared with 2% and 10% in Great Britain respectively. In addition, 43% of males and 35% of females in Scotland smoked cigarettes, while 36% of males and 32% of females in the General Household Survey reported the same behaviour. The consumption of healthy foods such as brown bread, salads, and fruits was also much lower in Scotland than in other parts of Great Britain. Therefore, it was not surprising that the Scottish Health Survey indicated that the proportion of males and females in poor health was much higher than in the General Household Survey. In the Scottish survey 51% of males and 49% of females stated that they were obese, whereas the proportions in the General Household Survey were 44% and 46% respectively.

Carstairs and Morris (1989) compared all cause mortality in Scotland with England and Wales. They calculated Standardised Mortality Ratios (SMRs) for premature mortality (0-64 years) all for all ages for Scotland in relation to England and Wales (whose SMR was 100), and reported values of 122 for premature mortality and 112 for deaths across all ages, subsequently highlighting that Scotland had considerably higher mortality than England and Wales. However, when they adjusted for deprivation, they found that the SMRs in England and Wales were 97 for both age groups, while in Scotland the SMRs for both groups were 103, indicating that deprivation accounted for much of the variation in mortality across the UK.

Shaw *et al.* (1998) examined the changing pattern of premature mortality (0-64 years) inequalities in Britain between 1951 and 1991. Their analysis was conducted using 292 areas, derived from County Boroughs and the urban and rural remainders of counties that existed in 1951. Standardised mortality ratios were calculated throughout the 40 years, and the authors reported 27 places that had higher than average mortality in 1981, and whose SMR had increased between 1981-1985 and 1990-1992, eight of which were located in Scotland. Of the eight Scottish localities, Greenock had the highest SMR in 1990-1992 (130), which was the third highest in Britain after Oldham and Salford, both of which had SMRs of 131. Rural Perth County had the lowest SMR of the eight Scottish localities of 106 in 1990-1992.

The authors reported that if the 27 localities that had increasingly high SMRs between 1981-1985 and 1990-1992 had reported SMRs equivalent to the national average in 1990-1992 (that is, an SMR of 100), then 22,400 premature deaths could have been prevented. Of the 22,400 excess deaths, 21% (4,680) could have been prevented in Scotland.

Shaw *et al.* (1999) used British Parliamentary Constituencies to assess the widening health gap between the 'best health million' and the 'worst health million', which were defined as a group of non-contiguous parliamentary constituencies that comprised approximately one million people, and which had the best or worst health. The 'worst health million' comprised of 15 parliamentary constituencies, nine of which were located in or adjacent to Glasgow City (Glasgow Maryhill; Glasgow Anniesland; Glasgow Kelvin; Glasgow Springburn; Glasgow Baillieston; Glasgow Shettleston; Glasgow Pollock; Glasgow Govan; and Greenock and Inverclyde). The remaining six parliamentary constituencies were located in Liverpool (Riverside), Greater Manchester (Blackley, Central and Salford), Newcastle (Tyne Bridge) and London (Southwark North and Bermondsey). There were 13 parliamentary constituencies in the 'best health million' category, all of which were located south of Sheffield. Each of the premature SMRs for the worst health million were above 150, with two of the constituencies in Glasgow (Springburn and Shettleston) reporting SMRs greater than 200 for the 1991-1995 period. The SMRs for Springburn was 217 while Shettleston had the highest premature mortality ratio, at 234.

Between 1981-1985 and 1991-1995 the standardised mortality ratio for all deaths occurring below 65 years of age increased in the 'worst health million' areas from 155 to 178. Glasgow Shettleston experienced the biggest increase over the period (50%), from 184 in 1981-1985 to 234 in 1991-1995. In contrast, the mortality ratios for the 'best health million' decreased from 76 in 1981-1985 to 68 in 1991-1995. The South Suffolk parliamentary constituency demonstrated the biggest reduction in premature mortality over the time period, reducing from 85 in 1981-1985 to 69 in 1991-1995, or 15% (Shaw *et al.* 1999). A closer investigation into the percentage changes in mortality experienced by different population groups showed that the constituencies in the best health million experienced decreases in mortality between 1981-1985 and 1991-1995 for all age groups (0, 1-4,5-14,15-44,45-64), except for West Chelmsford, which remained stable for the 15-44 age category.

While the majority of the constituencies in the worst health million experienced decreases, the pattern was inconsistent. For example, infant mortality (<1 year) increased by 19% in Southwark and Bermondsey, while the remaining 14 parliamentary constituencies showed reductions ranging between 2% (Glasgow Anniesland) and 50% (Glasgow Kelvin). The relative success observed for the worst health million constituencies for infant mortality were not paralleled for the other age groups, which ranged from large decreases (-27%, Glasgow Springburn, 1-4 years) to large increases (53%, Southwark and Bermondsey, 1-4 years). Of the Scottish members of the worst health million, three constituencies experienced declines between the ages of 15 to 44 years: Glasgow Kelvin (-20%); Glasgow Baillieston (-9%) and Greenock and Inverclyde (-9%). The remaining 6 Scottish constituencies suffered increases in the mortality rate between 1981-1985 and 1991-1995, ranging from 4% in Glasgow Anniesland to 28% in Glasgow Shettleston. Overall, the mortality rates for the worst health million increased by 7%, while the best health million decreased by –5% and consequently showed that the mortality gap for premature mortality widened in Britain between 1981 and 1995.

In addition to premature mortality from all causes, Shaw *et al.* (1999) used a number of indicators of health and poverty, such as long term illness, unemployment, changes in the workforce, and the proportion of children living in households where both parents did not work, to demonstrate the growing inequalities between the best health million and the worst health million. For example, they used the proportion of the population aged 16 years and over that had a permanent illness in 1981, and the proportion of the population who reported a limiting long-term illness in 1991 to examine the widening morbidity inequalities. It should be noted that these two variables were not directly comparable as no question regarding limiting long-term illness was asked in the 1981 census however, Dorling (1995) suggested that the permanent disability question from the 1981 census was a suitable proxy to aid comparisons through time. The constituencies in the worst health million experienced a 5% increase between 1981 and 1991, while the constituencies in the best health million increased by only 1.6%. Furthermore, all of the parliamentary constituencies in Glasgow reported increases of 5% or more, with health deteriorating most in Glasgow Baillieston, in which the proportion of permanently sick residents unable to work increased from 4% in 1981 to 11 percent in 1991.

Griffiths and Fitzpatrick (2001b) used life expectancy at the country, region, and local authority level in 1995-1997 for males and females separately to distinguish differences between the countries within the UK. They used the income and unemployment domains from the Indices of Deprivation (DETR 2000) as measures of deprivation and both domains demonstrated strong negative correlations with life expectancy. Thus, as the deprivation of an area worsened, so too did the average life expectancy of that area. For males, the correlation between life expectancy and unemployment was -0.73, while for the income domain the correlation was -0.71. The associations for females were slightly weaker, but still strong, with correlations of -0.60 for income and -0.63 for unemployment.

The life expectancy for Scottish males (72.3 years) and females (77.8 years) were the lowest reported for the countries of the UK. In contrast, England had the highest life expectancies for males (74.7) and females (79.8), a difference of 2.4 years and 2 years respectively. Regional differences were also evident. Griffiths and Fitzpatrick (2001b) ranked the local authorities whose life expectancy at birth in 1995-1997 was below 71.9 years for males and 77.7 years for females (the United Kingdom level for 1986), they found that for males, seven of the 16 local authorities were located in Scotland. Of the 25 local authorities that fitted the criteria for females, 16 were Scottish. Males born in the Glasgow City local authority during 1995-1997 had the lowest life expectancy at birth across the United Kingdom, at 68.4 years, which was also less than the life expectancy for males in the United Kingdom as a whole in 1966. Furthermore, there was a difference of 10 years between the life expectancy of Glasgow and Chiltern (Buckinghamshire), which had the highest life expectancy (78.4 years) for males.

The life expectancy for females born between 1995 and 1997 was worst in Glasgow City (75.4 years), which was 8.1 years less than for females born in East Dorset, who could expect to live for 83.5 years. The female life expectancy in Glasgow (75.4 years) was similar to the calculated life expectancy for females across the United Kingdom in 1976, and was 8.1 years lower than the life expectancy for females in East Dorset, who could expect to live for 83.5 years (Griffiths and Fitzpatrick

2001b).

Hanlon *et al.* (2001) also examined trends in mortality in Scotland in relation to the rest of the United Kingdom and Europe. For the United Kingdom component of their work, they partially replicated the work by Carstairs and Morris (1989) by calculating the Carstairs index of deprivation for the United Kingdom as whole, but used data from the 1991 census to construct their deprivation index. Hanlon *et al.* (2001) used the same seven deprivation categories (DEPCATs) as Carstairs and Morris (1989), and showed that significantly fewer Scots lived in the more relatively affluent areas (DEPCATs 1 and 2). From DEPCAT 3 downwards, the proportion of the Scottish population belonging to each DEPCAT became increasingly greater than the English and Welsh population (Figure 2-1). In addition, they found that of the four variables that were used to construct the index of deprivation for 1991, lack of car ownership demonstrated the largest difference between England and Wales and Scotland. Of the total Scottish population, 34% did not own their own car in 1991, compared with 24% of the population in England and Wales. The other three variables were all less than 5% higher in Scotland than in England and Wales. They used population weighted deprivation quintiles, based on the Carstairs index, and calculated mortality rates to determine the extent of inequalities between the least relatively deprived and most relatively deprived quintiles. Death rates were for all ages, and for the population aged 15-34, 35-64 and 65+, for Scotland and England and Wales separately. In all four age groups inequalities were higher in Scotland than in England and Wales, with the mortality gap widest for the population aged between 35 and 64 years, for which the death rate in quintile 5 was 2.02 times higher than for quintile 1. Furthermore, the Scottish death rates were higher than for England and Wales, for each quintile and for every age group.

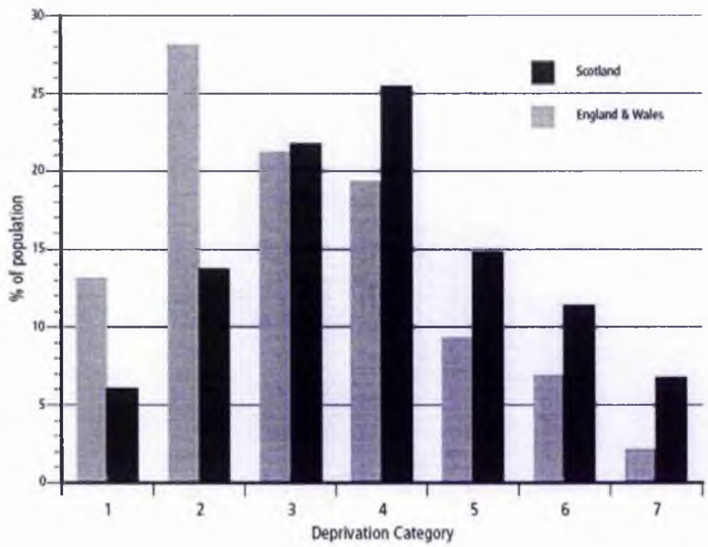

Figure 2-1 The proportion of the population in Scotland and England and Wales by deprivation category (DEPCAT). (Source: Hanlon *et al.* 2001)

To identify regional differences in mortality at all ages and premature mortality (0-64) within Scotland, Hanlon *et al.* (2001) aggregated their data into 13 Scottish regions, and calculated SMRs based on the death rates for England and Wales. Therefore, regions with an SMR of 100 had the same number of deaths that would be expected given the age and sex structure in England and Wales. For all age mortality, only the SMR for the Grampian region was less than the average for England and Wales, while the Shetland Islands was the only region to have an SMR of less than 100 for premature mortality. The Strathclyde region had the highest SMRs for both age groups.

For ratios standardised to the population of England and Wales, Hanlon *et al.* (2001) found that mortality was 13% higher in Scotland across all ages than expected (i.e. SMR=113). In addition, the SMR for Scotland for all deaths occurring below the age of 65 was 123.9. However, having controlled for age, sex and deprivation, the SMR reduced for all ages from 113.0 to 107.0 (46%) and therefore suggested that variations in deprivation between Scotland and England and Wales accounted for 46% of the excess mortality. Similarly, controlling for deprivation in addition to age and sex reduced the SMR for premature mortality from 123.9 to 110.0, which indicated that deprivation accounted for 56% of the excess mortality observed in Scotland.

Previously, Carstairs and Morris (1989) had undertaken similar analyses, calculating mortality ratios for Scotland relative to England and Wales using data centred on the 1981 census, and a reduction in the SMRs from 122 to 103 for all age mortality and from 112 to 103 for premature mortality, once deprivation was controlled for. Therefore, in 1981 deprivation explained 86% and 75% of the excess mortality found in Scotland when compared with England and Wales. The results reported by Hanlon *et al.* (2001), which were based on the 1991 census, suggested that the Carstairs index of deprivation (Carstairs and Morris 1989, 1991) could no longer explain all of the differences between the SMRs for Scotland and England and Wales. The inability of deprivation to explain inequalities in mortality in 1991 was referred to as 'The Scottish Effect'.

Hanlon *et al.* (2001) suggested two broad possible explanations regarding the emergence of the Scottish Effect. The first was that the variables used in the construction of the Carstairs index were no longer efficient markers of deprivation, and that by 1991 they had lost their discriminatory ability. Second, they suggested that the differences between Scottish mortality and the rest of the United Kingdom were the result of differences in the exposure to social, psychological and/or behavioural factors that increase risks of premature death.

To date, no analysis has been undertaken to determine whether the Scottish Effect has persisted throughout the 1990s and into the new Millennium. However, focusing on health related behaviour, Griffiths and Fitzpatrick (2001a) reported that the proportion of adults aged 16 years and older that smoked cigarettes was higher in Scotland than England, Wales, and Northern Ireland. Using data from the General Household Survey of England and Wales, and the Continuous Household Survey in Northern Ireland, Griffiths and Fitzpatrick (2001a) showed that approximately 34% of Scottish adults smoked, while between 25% and 30% of adults in England, Wales and Northern Ireland were smokers. Moreover, the Scottish smoking rate was higher than the smoking rates reported for each of the Regions of England, although the proportions of smokers in the North East and North West Regions were similar to Scotland as a whole (approximately 32% and 30% respectively). Cigarette smoking has been a known cause of lung cancer since Doll and Hill (1950) showed in a case-control study of females diagnosed at a

London hospital, that 2.5 times more smokers than non-smokers were diagnosed with lung cancer.

The areas of relatively high smoking incidence as identified by Griffiths and Fitzpatrick (2001a) were also reported to have the highest lung cancer mortality rates. For males at all ages, the mortality rate for lung cancer in Scotland was 100 per 100,000, compared with 76 per 100,000 for the United Kingdom as a whole. Furthermore, for males aged 65 and older the rate in Scotland was 630 per 100,000, some 45% higher than Northern Ireland (436 per 100,000), the country within the United Kingdom with the lowest cancer mortality rate.

Griffiths and Fitzpatrick (2001a) examined all cause mortality and deaths due to accidents; cancers (all, breast, colorectal, lung, prostate); circulatory diseases (ischaemic heart disease and stroke); drug and alcohol misuse; infectious diseases; respiratory diseases; and suicide in the United Kingdom by country, region, local authority, and ONS area classification group (ONS 1999) during the 1990s. For many of these causes, the highest mortality rates, for males and/or females across some or all of the age groups studied (all ages, 15-44, 45-64 and 65+), were found in Scotland. Analysis of variance to determine how much the variation in mortality rates by the local authorities in Great Britain were explained by the country or region of location, and how much variation was accounted for by the ONS area classification (Bailey *et al.* 1999). For most causes of death, these factors explained between 60% and 85% of the variation, although their explanatory power was considerably weaker for cancer of the breast in females and prostate cancer in males (30%-40% each). However, the weak associations might not be surprising given the inverse relationship between the deprivation and these cancers (e.g. Benach *et al.* 2001)

More recently, Leyland (2004) used multi-level modelling techniques to examine trends in mortality between 1979 and 1998. The smallest level of observation was the Local Government Authority in England and Wales and the Local Government District in Scotland, which nested within counties that aggregated further into regions. Over the 19 years examined, the SMR for all cause premature mortality reduced from 179 to 157 in 1998, indicating a 36% reduction in mortality. However, the decline in SMRs varied geographically. For example, Scotland demonstrated the smallest reduction, with SMRs reducing by 33% from 191 in 1979 to 128 in 1998. In contrast Wales exhibited a reduction of 42% in mortality from 165 in 1979 to 96 in 1998. Furthermore, those regions that had the highest mortality rates in 1979 showed the smallest improvements over time, which concurs with the notion that more healthy areas experience health improvements faster than the less healthy areas.

Within regions, the mortality gap between districts with high and low mortality increased between 1979 and 1998. The mortality gap within Scotland was most striking in the Greater Glasgow District. In 1979, Glasgow City had the worst premature mortality with an SMR of 230.1, while Bearsden and Milngavie had the lowest SMR of 136.6. The poor mortality in Glasgow City remained highest in the Greater Glasgow District and had an SMR of 217.6 by 1998, whilst the Eastwood District, which is adjacent to the Greater Glasgow District, had the lowest mortality ratio in 1998, of 77.1. Thus, by dividing the lowest SMR by the highest SMR for each period, Leyland (2004) demonstrated that relative inequalities in Glasgow had widened from 1.68 in 1979 to 2.82 in 1998.

In addition, Leyland (2004) calculated the percentage of excess mortality for regions in Great Britain, relative to the mortality risk in the East of England region, where mortality risk was lowest. Most regions experienced between 10% and 20% excess mortality throughout the 19 year period. The proportion of excess mortality in Scotland was approximately 23% in 1979 and never fell below 20%. Since 1981, when excess mortality reached its lowest point for Scotland, excess mortality has increased considerably to 33% again. In contrast, the excess mortality in Wales reduced from 14% in 1979 to 9% in 1998, demonstrating the lowest excess mortality relative to the East of England.

This section has demonstrated that in terms of mortality, Scotland has considerably worse health than other constituents of the United Kingdom. While Carstairs and Morris (1989; 1991) demonstrated the differences in mortality between England and Wales and Scotland could largely be explained by their index of deprivation, recent research by Hanlon *et al.* (2001) showed that the index of deprivation calculated from the 1991 census no longer explained the variations in mortality between Scotland and England and Wales.

The Black Report (Townsend *et al.* 1992) was undoubtedly influential in shaping research and policies designed to reduce health inequalities, throughout the UK and internationally. Yet, despite the abundance of academic research and Government policies targeting the reduction of health inequalities, recent evidence (e.g. Shaw *et al.* 1999; Leyland 2004) has revealed that the health disparities – in Scotland and elsewhere – have continued to worsen over time for most health outcomes. However, the geographic scale at which these studies were investigated (e.g. parliamentary constituencies (Shaw *et al.* 1999); and Regions (in this case, the whole of Scotland) (Leyland 2004), hides the fact that variation in health outcomes could exist within Scotland, which is the focus of the following section.

2.4. Mortality Trends Within Scotland

The annual number of deaths in Scotland has steadily decreased during the 20th Century, from 78,021 in 1900, to 59,478 in 2000. Milestones were observed in the early 1920s, when the number of deaths fell below 70,000, and again in 1953, when there were less than 60,000 deaths per year for the first time. However, the number of deaths rose again in 1954 and only fell below 60,000 again in 1967 and then in 1994, after which the annual number of deaths has hovered around 60,000. Since the 1920s, the number of deaths followed a relatively stable decline, and never rose above 67,652: the 1921-1925 average. By 2001, there were 57,382 deaths in Scotland per annum, some 6% lower than the number of deaths in 1991 (61,171) (GROS 2002).

Over the course of these 100 years, there have been many changes to the composition of mortality in Scotland, in terms of the age and sex distribution and the primary causes of death. For example, the infant mortality rate was 129.5 per 1,000 live births in 1900, but reduced significantly to 5.5 per 1,000 live births in 2001. Improvements in medical care, immunisation against a range of infectious disease, and improvements in living conditions have been largely responsible for this significant reduction (GROS 2002).

McLoone (2003) examined the changes in mortality rates between 1981 and 1999, and reported that the age-standardised death rates for all ages decreased from 1,611 per 100,000 in 1981-1983 to 1,261 per 100,000 in 1997-1999 for males and from 1,476 per 100,000 in 1981-1983 to 1,253 per 100,000 in 1997-1999 for females. However, McLoone (2003) also showed that the changes observed for the total population were not evenly distributed by age group or by sex. For example, the death rates for males aged 75 and over decreased from 13,764 (per 100,000) in 1981-83 to 12,527 in 1989-1991 and reduced further to 11,261 in 1997-1999. In contrast, the death rates amongst males aged 15-29 decreased from 98 per 100,000 in 1981-1983 to 93 per 100,000 in 1989-91, but subsequently increased to 108 per 100,000 in 1997-1999.

During the 20th Century Scotland, like most developed countries, experienced an epidemiological transition whereby the primary causes of death changed from being infectious diseases to chronic diseases such as cancers, and ischaemic heart disease. This trend is elucidated in Figure 2-2, which shows the significant decrease in infectious diseases and contrasting increases in cancers (neoplasms) and circulatory diseases (e.g. ischaemic heart disease and stroke).

Despite the absolute number of deaths in Scotland reducing throughout the Century, some of the trends are very worrying. In particular, the proportion of deaths due to cancers increased steadily from 4.26% of all deaths in 1900 to 26.39% in 2001. At the beginning of the century, infectious diseases accounted for 13% of all deaths in Scotland and peaked at 16.12% in 1925. In the following 50 years, infectious diseases decreased substantially, which was largely due to the development of immunization schemes, such that by 1975 only 0.65% of deaths resulted from infectious diseases. In the last quarter of the 20th Century, there was a slight increase in infectious disease related deaths; some of these deaths were due to the emergence of the Acquired Immune Deficiency Syndrome (AIDS).

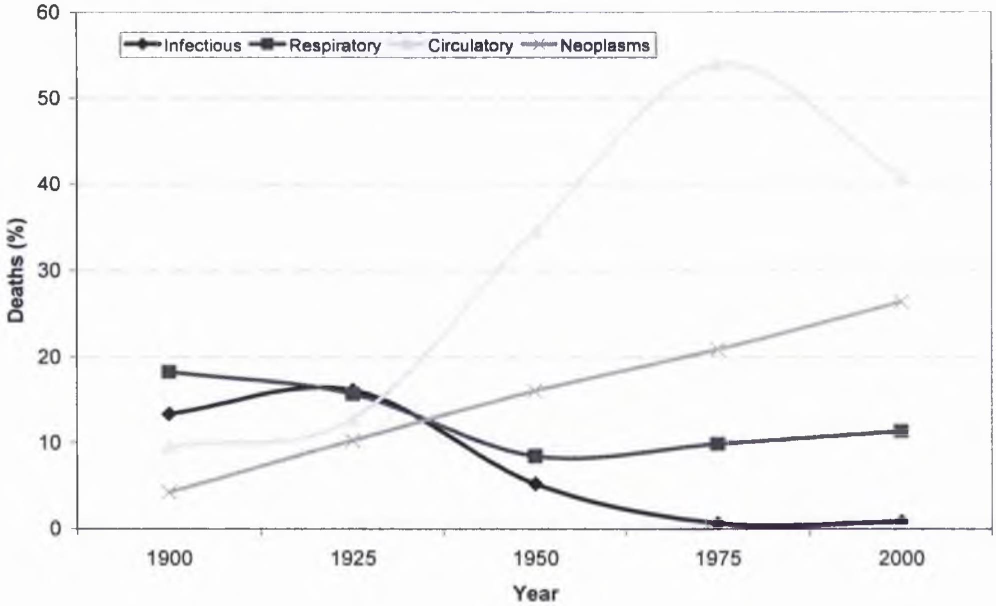

Figure 2-2 The proportion of deaths from selected causes in Scotland during the 20th Century (Source: GROS 2004a)

In addition to changes in the causes of death and the age distribution of mortality within Scotland, geographic variations in mortality have also been observed. For example, Watt and Ecob (1992) analysed trends in all cause and cause specific mortality for the population aged 25 to 74 years between 1931 and 1981 in Glasgow and Edinburgh. They showed that although mortality rates had declined over the period, there were marked differences between the two cities, with mortality in Glasgow being consistently higher than Edinburgh between 1961 and 1981. Furthermore, they found that on average, there was a lag of between 20 and 30 years between the present mortality rate for Glasgow and the comparable rate previously found in Edinburgh.

Watt and Ecob (1992) calculated mortality ratios between 1979-1983 for Glasgow standardised to the death rates in Edinburgh (i.e. Edinburgh = 100). They reported SMRs for deaths from all causes in Glasgow of 144.5 for males aged 25-64 and 135.0 for females in the same age group. Among this age group for males, there was relative stability between the SMRs for specific causes, with SMRs ranging between 142.0 and 143.0 for heart disease, stroke and 'other causes'. Death from cancer among males was slightly lower than average for males in Glasgow, with an

SMR of 133.6. However, SMRs varied for different age groups. For example, the SMR for stroke mortality among males aged between 35 and 44 was 277.6 ($p=0.01$)

Among females aged 25-64, the cause specific SMRs in Glasgow were also considerably higher than in Edinburgh, but were more variable than for males. Of the four groups of diseases examined (stroke, heart, cancers, other), the SMR for stroke was highest, at 155.1. Heart disease (143.7) and 'Others' (132.5) were also reasonably high, but the SMR for cancers (115.7) was substantially lower than for all cause mortality. While variation was demonstrated between age groups, rates for stroke mortality were still the highest among females aged 35-44, at 396.3 ($p<0.05$).

In addition, Watt and Ecob (1992) showed that in 1959-63, the death rates among males and females in Glasgow were comparable to the rates for males and females 2.4 and 2.8 years older in Edinburgh. However, as mortality reduced in Edinburgh and remained stable in Glasgow over time, they predicted (based on statistical modelling) that by 1989-1993 the differential would be 5.1 years for males and 3.9 years for females. The authors suggested that the differences in mortality were due to differences in the risk factors known to be associated with some of the cause specific deaths that were evaluated. For example, men in Glasgow recorded higher mean systolic blood pressure, alcohol intake and smoking prevalence, and ate less fruit and vegetables than men in Edinburgh. These factors are known to be associated with heart disease and lung cancer. Because two of the Districts neighbouring Glasgow (Eastwood, and Bearsden and Milngavie) had SMRs considerably lower than Edinburgh (14% and 17% respectively), differences in the physical environment (e.g. climate) were not considered to explain these differences.

McLoone and Boddy (1994) updated the work by Carstairs and Morris (1989) by examining the differences in Scottish mortality between 1981 and 1991 by DEPCAT. Whereas Carstairs and Morris (1989) examined all cause premature mortality, McLoone and Boddy (1994) also examined trends in cause specific mortality. They graphed results from locally weighted regression and compared the deprivation scores obtained for each Postcode Sector in Scotland for 1981 and 1991. Amongst the more affluent DEPCATs, there was very little difference between 1981 and 1991, but as deprivation worsened (i.e. DEPCATs increased), more pronounced differences between 1981 and 1991 were evident.

The premature (0-64 years) death rate decreased from 400 per 100,000 in 1980-1982 to 311 per 100,000 in 1990-1992, but analyses of specific age groups by DEPCATs showed considerable variations. McLoone and Boddy (1994) grouped the DEPCATs into three groups (1-2, 3-5, and 6-7), and for all cause mortality reported death rates for 10-year age bands for the population aged between 20 and 69. For males and females across all age groups, there were reductions in the death rates for the affluent group of DEPCATs (1-2). For example, the death rate for young males aged between 20 and 29 years decreased from 82 per 100,000 to 78 per 100,000, while larger reductions were seen in males aged 60 to 69, from 2858 per 100,000 in 1980-1982 to 2195 per 100,000 in 1990-1992. In contrast, increases in the death rates were found for males and females aged between 20 and 29 in the most deprived group (DEPCATs 6 and 7). The rate for young deprived males (20-29) increased from 123 per 100,000 in 1981 to 159 per 100,000 in 1991, an increase of 29%. Similarly, the rates for young deprived females rose from 57 per 100,000 to 63 per 100,000, representing an increase of 11%.

In their analyses of cause specific mortality, McLoone and Boddy (1994) considered changes in suicide, undetermined deaths, accidents and all other causes for the population aged between 20 and 29. In addition, they analysed changes in deaths from: ischaemic heart disease; cancer of the trachea, bronchus and lung, female breast cancer, all other cancers; and all other causes for all persons aged between 40 and 64 years. In the younger age group, deaths from suicides and undetermined deaths increased by 45% and 62% respectively, while reductions were reported in accidents (23%) and all other causes (3%). Substantial differences were found between the three deprivation categories, the most deprived group of areas (DEPCAT 6 and 7) reported increases of 59% in suicides and 109% in undetermined deaths. In contrast, the more affluent group (DEPCAT 1 and 2) showed the lowest increase in suicides (37%) and the average group (DEPCATs 3, 4 and 5) had the smallest percentage increase in undetermined deaths between 1981 and 1991 (40%). A more consistent trend was observed for accidents, whereby the most affluent group showed a 43% reduction over the decade, followed by the average deprivation categories (-24%) and the most deprived deprivation category only experiencing a 10% reduction. For all other causes, no change was reported in DEPCATs 1 and 2, whereas DEPCATs 3, 4, and 5 reduced by 10% and the most deprived group increased by 17%.

For the older age group (40-64), McLoone and Boddy (1994) presented a more favourable trend in mortality, with each deprivation group experiencing reductions for all of the causes of death examined, except for an 11% increase in 'other cancers' reported for the most deprived category (DEPCATs 6 and 7). The general trend observed for the older age group was that the affluent areas experienced bigger reductions than the deprived areas. Mortality from ischaemic heart disease reduced by 40% between 1981 and 1991 in the most affluent group, compared with a reduction of only 20% in the most deprived category. Female breast cancer was the only cause of death that demonstrated a reversal in the trend, whereby the deprived areas exhibited a 19% reduction compared with a decrease of 8% in the affluent group. This was consistent with other studies that have examined the social gradient in breast cancer.

MacIntyre *et al.* (2001) analysed mortality from first myocardial infarction ('heart attack') between 1986 and 1995 by deprivation. They constructed the Carstairs index from the 1991 census and allocated a deprivation quintile to each event based on the postcode of the usual residence. In total, 83,175 males and females died from myocardial infarction prior to admission to hospital during the study period. An additional 117,749 deaths occurred after admission to hospital. The authors showed that individuals living in the most deprived areas were twice as likely to suffer a fatal heart attack prior to hospital admission, and that the effect was stronger for females than for males. In hospital, males and females under 65 years living in deprived areas had a 20% greater risk of dying as result of the heart attack than victims living in less deprived areas. It was suggested by the authors that over the study period, there were 2,000 excess deaths among residents of the most deprived areas.

There have been a number of more localised studies based in Scotland that have provided a breadth of information regarding health inequalities and the importance of societal conditions across the lifecourse. For example, the Collaborative Study (Blane *et al.* 1996) was originally designed as a cross-sectional study, based on a sample of 6,022 males and 1,006 females that were recruited from 27 workplaces in Glasgow, Clydebank and Grangemouth between 1970 and 1973. Participants underwent a 20-minute examination where researchers obtained a range of information including early life conditions, (father's occupational social class), height, weight, blood pressure, cholesterol, and respiratory function. In 1977, participants were invited to participate in a follow-up examination, which attracted a response rate of approximately 50%. Since 1996, these data have been linked with hospital admissions data and death records from the GROS, thus creating a prospective study of health in the West of Scotland.

The Collaborative Study was used to determine the influences that lifecourse socio-economic and behaviours had on cardiovascular mortality (Davey Smith and Hart 2002). Their analysis included smoking and drinking behaviour, as well as Carstairs deprivation, the occupational social class of the participant and his or her father, and the age of leaving full-time education. Those participants whose fathers had a manual occupation and who reported an unfavourable lifestyle behaviour (i.e. current smokers), reported significantly higher relative rates than those participants whose fathers worked in a non-manual occupation and who had a favourable lifestyle behaviour (i.e. non-smokers). For example, current smokers whose fathers were from a manual background were 3.11 times more likely to die from cardiovascular disease than participants who were not current smokers and whose father had a non-manual occupation.

By combining four of these variables (father's and own social class, smoking and alcohol consumption), Davey Smith and Hart (2002) determined the cumulative risk of cardiovascular disease. Participants were categorised by their health behaviours, and the increased risk of mortality was calculated relative to having four 'favourable' lifestyle behaviours (non manual social class for participant and for father, non-smoker, and alcohol consumption less than 15 units per week). Those participants who had only one 'unfavourable' health behaviour were 1.99 times more likely to die from cardiovascular disease than those with no unfavourable health behaviours. This increased to 2.60 for 2 unfavourable risks, and increased to 2.98 for those with 3 unhealthy risks. However, those participants that had all four unfavourable conditions were 4.55 times more likely than those participants that led relatively healthy lifestyles.

In summary, this section has outlined that, with regard to mortality, there is considerable variation between areas *within* Scotland. A majority of the research into the geographic inequalities in mortality within Scotland have aggregated data mortality data into administrative units such as Health Boards (Carstairs and Morris 1991) and postcode sectors (McLoone 1996), or have used deprivation indices, particularly the composite index developed by Carstairs and Morris (1989; 1991) to distinguish between the 'most deprived' and 'least deprived'. Each study has identified that there is a considerable gradient of inequalities, and many have suggested approaches to alleviate inequalities. The next section discusses the extent to which policies have used the evidence from the literature, and examines whether the policies implemented may help reduce geographic inequalities.

2.5. Government Responses

The Scottish Executive has recognised that Scotland has comparatively poor health and has made a commitment to reducing health inequalities within Scotland and in relation to other countries within the United Kingdom and the European Union. The Scottish Office[2] (1999a) published a White paper that outlined a strategy designed to reduce health inequalities, in which three levels of action were defined.

Life circumstances was the first action level and focused on improving socio-economic conditions. Initiatives designed to improve life circumstances included the development of Social Inclusion Partnerships, better economic support for families with children, improving housing conditions, providing better access to employment and training opportunities, better environmental conditions and better community care for people with disabilities. At present, there are 34 area-based SIPs in Scotland, and a further 14 thematic initiatives that target the general population (e.g. 'younger people and health'). SIPs are community-focussed and represent a partnership between the residents in a community and their local authority and other administrative organisations such as health boards, and organisations from the voluntary and private sectors. Furthermore, some of the

[2] Now the Scottish Executive

philosophies behind the development of the SIPs were based on the Wilkinson hypothesis (Wilkinson 1996), which suggests that psychosocial factors and social cohesion are important factors in reducing health inequalities.

Initially 29 milestones were established to quantify the performance of programmes such as the SIPs (The Scottish Office 1999b). The most recent evidence suggested that only 2 of the 29 milestones (reducing the number of households in temporary accommodation and reducing the frequency of exclusion from or truancy) were not moving in the desired direction. Of the remaining 27 indicators, 17 were following projected trends, while 9 indicators had not experienced any change. There was insufficient data regarding the reduction of crimes, so the trend was not assessed (The Scottish Executive 2003).

The second level of the White paper targeted *lifestyles*, which aimed to reduce poor health behaviours such as cigarette smoking, drug and alcohol misuse, as well as increasing physical activity and encouraging a more healthy diet. The Scottish Office (1999a) suggested that reductions in smoking could be achieved by banning tobacco advertising, improving health promotion, reducing exposure to passive smoking, and tougher penalties for the sale of tobacco to children under 16 years old. Similarly, guidelines for the reduction of drug and alcohol misuse would also be established, in conjunction with improved prevention and treatment services to reduce drug misuse. A national strategy to improve the Scottish diet was initialised in 1996 (The Scottish Office 1996), which established recommendations that affected primary producers, manufacturers and processors, retailers, the community, pregnant women, and children from pre-school to secondary school ages.

The third level that the Scottish Office outlined for action, *health topics,* targeted the reduction of premature deaths and illness in Scotland. To reduce premature deaths, the White Paper aimed to promote the health of children, through educating parents on topics such as: childhood nutrition; healthy diets, reducing accidents during childhood and immunisation. In particular, the dental health of children under 5 years of age were targeted, since the poorest 10% of children had over 50% of the tooth decay reported in surveys of Scottish children aged 5, 12 and 14 years old (The Scottish Office 1999a). In addition to dental health amongst children, the

White paper aimed to improve the sexual health of young teenagers, by reducing the pregnancy rate amongst 13-15 year olds by 20% between 1995 and 2010.

The White paper also targets reductions in coronary heart disease and cancers, as between them these two causes of death accounted for over 47% of all deaths in Scotland in 2001. Many of the life circumstances and lifestyle factors targeted in the White paper have been developed to reduce mortality from these causes. In addition, cancer and heart disease have become leading priorities for the NHS in Scotland and a number of health promotion programmes have been developed to educate the general population of the health risks associated with smoking, binge drinking and poor dietary behaviours.

Four 'Health Demonstration Projects' were created from the White Paper: *Starting Well; Healthy Respect; The Heart of Scotland* and *The Cancer Challenge*. These projects have been designed to focus initiatives focused at sustaining improvements in the health and well being of the Scottish population across all ages. The Starting Well project promotes the health of young people from pre-conception through to primary school age. The Healthy Respect programme promotes responsible sexual health practises among teenagers and pays particular attention to teenage pregnancies and sexually transmitted diseases. Preventing heart disease is the focus of the Heart of Scotland project, which promotes the importance of a healthy diet, physical activity and drinking alcohol in moderation. Furthermore, through the Heart of Scotland demonstration project, the Scottish Office aimed to reduce the occurrence of stroke and some cancers. Finally, the Cancer Challenge focused the early detection of colorectal cancer, which would complement the existing breast and cervical cancer screening programmes.

Thus, the overarching aim of Towards a Healthier Scotland' (The Scottish Office 1999a) was to tackle health inequalities. Table 2-2 lists the *headline targets* that were established to quantify the improvements in the health of Scotland between 1995 and 2010. A 50% reduction in coronary heart disease translates to a reduction from 143 deaths per 100,000 in 1995 to 72 per 100,000 by 2010. Since 1990, coronary heart disease has been decreasing steadily, and by 2001 the rate had decreased to 100 per 100,000. Thus, providing that the existing trends remain, the coronary heart disease target will be met (HEBS 2003a).

A 20% reduction in premature cancer mortality refers to a decline in the death rate from 188 deaths per 100,000 in 1995 to 150 deaths per 100,000 in 2010. Unlike coronary heart disease, the cancer mortality trend during the 1990s and early 2000s has been more erratic, with two considerable increases in the death rates. The first increase occurred in 1993 when the cancer rate rose from 184 per 100,000 to 194 per 100,000 – higher than the 1990 rate of 191 per 100,000. The death rates decreased sharply to an all time low of 172 per 100,000 in 2000 before increasing again to 177 per 100,000 in 2001, back to the same rate observed in 1998 (HEBS 2003b). Prior to 2001, the trend for cancers appeared to be on target to reach the milestone death rate of 150 per 100,000, however the subsequent increase in 2001 might impede the success of the health interventions.

Health outcome	*Headline Target (1995-2010)*
Coronary Heart Disease	Reduce premature mortality by 50%
Cancer	Reduce premature mortality by 20%
Smoking	Reduce smoking among 12-15 year olds from 14% to 11%
	Reduce proportion of females smoking during pregnancy from 29% to 20%
Alcohol Misuse	Reduce incidence of exceeding weekly drinking limits from 33% to 29% for males and from 13% to 11% for females
Teenage Pregnancy	Reduce rate among 13-15 year olds by 20%
Dental Health	60% of 5 year old children with no experience of dental disease

Table 2-2 The Scottish Office's headline health targets, designed to monitor improvements in health inequalities between 1995 and 2010 (Source: the Scottish Office 1999a).

In addition to the White paper, the Scottish Executive has published a range of policies and publications directed at reducing inequalities. For example one of the core objectives in 'Our National Health' (The Scottish Executive 2000) was to reduce health inequalities. Our National Health emphasised the importance of reducing poverty, poor housing conditions, and improving education and economic opportunities in order to reduce health inequalities. Furthermore, a major component of Our National Health was the Scottish Executive's commitment to improving the National Health Service in order to better equip services to help reduce inequalities.

The Inequalities in Health Report (Measuring Inequalities in Health Working Group 2003) reviewed 30 variables derived from administrative datasets, the Scottish Health Surveys, and the Scottish Household Survey, to establish 23 suitable indicators of health and health inequalities across the life course. The population was divided into four groups: 0-9 (children); 10-14 (young adults); 16-74 (adults); and 75+ (older people) in the Inequalities in Health Report. The Working Group recommended the use of the Carstairs index of deprivation (Carstairs and Morris 1989; 1991) as a measure of social deprivation. Furthermore, the ratio between the least deprived and most deprived quintiles was recommended to measure the relative gap between the rich and poor. However, the Working Group felt that there was no clear evidence-base on which to recommend specific targets, and therefore did not recommend any further targets for reducing health inequalities. Nonetheless, the Working Group reported the ratio of inequalities between the least deprived and most deprived quintiles for each of the 23 recommended indicators of inequalities, which can be compared through time.

The Scottish Executive has therefore expressed its commitment to reducing health inequalities in Scotland. In response to the evidence in the literature, The Scottish Executive has identified several key health targets, including the reduction of mortality from cancer and heart disease by at least 20% by 2010. To achieve these goals, a framework for monitoring health inequalities has been established, in which changes in relative inequalities are being used to assess the success of policies in place that aim to improve the health of the Scottish population. The Scottish Executive has invested in programmes designed to raise public awareness of the adverse health affects of smoking, binge drinking, and a poor diet, which contribute to high levels of lung cancer, liver cirrhosis, and heart disease. Other initiatives, such as the Social Inclusion Partnerships (SIPs), are based on the Wilkinson hypothesis (Wilkinson 1996), which suggests that psychosocial factors and social cohesion are important factors in reducing health inequalities.

2.6. Conclusions

Mortality in Scotland has been declining steadily since early in the last century, however, this chapter has shown that the Scottish mortality profile has changed considerably since 1901. During the second half of the 20th Century Scotland, like most developed countries, underwent what Omran (1971) defined as the epidemiological transition, which saw a considerable reduction of deaths due to infectious and parasitic diseases and subsequent increases in chronic diseases such as cancer and heart disease. In the wider context, mortality in Scotland was shown to be considerably worse than other parts the United Kingdom and Western Europe. Although death rates are decreasing in Scotland, the improvements that have occurred in the past 50 years have not been as emphatic as those reported for other countries. Consequently, Scotland or some of the regions within Scotland, regularly feature at, or near the top of, 'league tables' for having notably high mortality trends.

Furthermore, this review chapter has demonstrated that there are a number of disparities inherent in the Scottish mortality trends. First, it was shown that death rates at early ages (0-4 years) and among the elderly (75+) have been decreasing since the 1980s, while death rates for young adults, particularly among males aged between 15 and 29 years of age, increased between 1991 and 1999. McLoone (2003) suggested that this increase observed in young males could largely be explained by increases in alcohol and drug related mortality and suicides.

Second, social inequalities in mortality were demonstrated, in which people living in the most deprived parts of Scotland had substantially higher mortality rates than people living in less deprived parts of Scotland. Moreover, in spite of a number of health-promoting initiatives designed and implemented by the Scottish Executive to curb such inequalities, the literature suggests that the mortality gap between the least deprived and most deprived areas has also widened since the 1980s.

Third, mortality within Scotland was shown to vary between areas, with areas in the West of Scotland, in particular Glasgow and the adjacent zones having notably higher mortality than other parts of Scotland. Furthermore, it was shown that on average, rural areas experienced better than average health, while urban areas exhibited worse than average mortality.

The Scottish Executive has developed and implemented a number of initiatives in order to improve Scotland's standing in the European mortality 'league tables'. Specifically their White Paper, Towards a Healthier Scotland (The Scottish Office 1999a), identified six headline health targets (Table 2-2) each of which aimed to improve the health of the population at different stages of the life course. In addition, Our National Health (The Scottish Executive 2000) emphasised the importance of tackling inequalities in a wider societal context, such as reducing poverty, improving housing conditions, and increasing education and employment opportunities. The Inequalities in Health Report (Measuring Inequalities in Health Monitoring Group 2003) reviewed an exhaustive list of health indicators and recommended 23 variables derived from administrative datasets that should be used to measure health inequalities in Scotland.

Of the studies discussed here, the Postcode Sector (or Ward in studies involving England and Wales) was the smallest aggregation at which research was undertaken (e.g. Boyle *et al.* 2004a; forthcoming; Carstairs and Morris 1989, 1991; McLoone 1996, 2003; Hanlon *et al.* (2001). Many studies claim to have considered 'local' variations in mortality, although when the smallest level of analysis is the parliamentary constituency or council area, it is likely that many small area variations or 'pockets' of high or low mortality are masked. These studies have been undertaken at such coarse spatial resolutions because the smaller geographical areas used to disseminate the census area statistics, such as Enumeration Districts or Output Areas, change with each decennial census. Within Scotland, the Health Board is the only administrative unit that has not experienced any significant boundary changes since 1974, thus making the construction of consistent space-time series datasets at a local level difficult.

Traditionally, for the analysis of small area variations through time, researchers have been required to apportion data from one or more data sources into a common geographical configuration. The apportionment process, sometimes known as spatial interpolation, typically involves population estimation techniques that introduce further error into the source data.

The following Chapter introduces the data and methods used throughout this study. First, the mortality datasets from 1980-1982, 1990-1992 and 1999-2001 are described in detail, before discussing the calculation of standardised mortality ratios (SMRs), the method used to compare trends in mortality throughout this study. Next, a discussion of Scottish census geography for 1981, 1991, and 2001 is provided, paying particular attention to the configuration of the small area census boundaries used to disseminate data from these three censuses. The Chapter concludes with a description of the data and methods used to calculate the Carstairs index of deprivation (Carstairs and Morris 1991), which is used throughout the study as a marker of social circumstances.

3. Data and Methods

3.1. Introduction

The previous Chapter established that Scotland has a comparatively poor health experience compared to other countries in Europe. Furthermore, the Chapter emphasised that existing studies that examine health inequalities over time are generally conducted for large geographic areas. Consequently, this study aims to examine health inequalities at a relatively local level, using mortality data from 1980-1982, 1990-1992, and 1999-2001.

This research uses Scottish mortality data obtained from the General Register Office for Scotland (GROS) and social data derived from the 1981, 1991 and 2001 censuses. During the 21 years with which this study is concerned (1980-2001), a number of changes affected the classification of the deaths in Scotland; while the structure or format of census questions and the configuration of the small area census boundaries also changed considerably over time. However, this chapter only considers changes to health and social data that are relevant to this Scottish Study.

This chapter begins by describing the mortality data used in this study, and defines the main causes of death analysed in Chapter Five. In addition, consideration is given to the Census data employed in the analysis, before describing the generic methods used to examine mortality trends over time. During the analytical chapters a series of innovative approaches have been developed to evaluate particular research questions. In these cases, the methods used are discussed in the relevant section of the thesis.

3.2. The Scottish Mortality Dataset

3.2.1. Description of Data Used

Individual death records for 1980-1982, 1990-1992, and 1999-2001 were obtained from the General Register Office for Scotland (GROS). These periods were chosen because they were centred on the 1981, 1991, and 2001 censuses respectively, and because three years of data would smooth any extreme values that might occur from one year of data. Furthermore, the three years of mortality data can be pooled together in order to provide more data for rare events, such as suicide. Note the mortality data cover the period 1999-2001, rather than 2000-2002, because at the time of data extraction, mortality data for 2002 were not available. For simplicity, the mortality data for each period are referred to by their corresponding census year, for example, 1980-1982 are frequently referred to as '1981 mortality data'.

Each mortality record contained the age, sex, occupation, social class, marital status, month and year of death, and the underlying, or principle, cause of death. Furthermore, each record was provided with a 1991 Output Area (OA) and Postcode Sector identifier in order to determine where the deceased lived. Furthermore, rather than the full postcode of the deceased's usual residence, the 1991 OA was used to preserve confidentiality. Mortality data from all three periods were provided with a 1991 OA as the area identifier because there were no geographically correct Enumeration District (ED) boundaries available for 1981, and the census data for 2001 were not released when the data were initially extracted.

Throughout the study, inequalities are evaluated for mortality from all causes and for a selection of specific causes (accidents, cancers, stroke, heart disease, respiratory disease, suicide, all other causes combined). These causes of death were chosen for analysis either because these causes account for the majority of deaths in Scotland, or because these causes of death were rated poorly in the mortality League tables (Leon *et al.* 2003). The exception to this rule is accident-related mortality, for which Scotland compares favourably with other countries. Furthermore, these broad causes of death have been used by the GROS for reporting mortality trends (e.g. GROS 2001a).

3.2.2. Registering a Death in Scotland

The Registrar of Births, Deaths and Marriages must be informed of a death within eight days of an individual dying, and this can be reported by a relative, the occupier of the premises where the death occurred, or by any person present at the death. The person registering the death provides the Registrar with the date, time, and location of the death, as well as the full name, address, marital status, occupation, and country of birth of the deceased. If the deceased was married, divorced or widowed, then the full name of the spouse, and occupation of the husband (where appropriate) is submitted, and if the deceased was married at the time of death, the date of birth of the surviving spouse is also registered. The maiden name of the deceased's mother, and the occupation and full name of the deceased's father are also required at the time of registration. The name and address of the individual's doctor, and bank account details of the deceased are also provided to the Registrar.

Upon completion of the death registration, the informant is provided with a "Certificate of Registration of Death", which must be given to an undertaker before funeral arrangements can take place. In addition, another form is provided by the Registrar that allows the bereaved to obtain or adjust social security benefits, and for National Insurance purposes.

When a death has been registered, the GROS classify the cause of death based on the information submitted on the death registration, and according to the International Classification of Diseases (ICD). However, if a person dies suddenly; if the death appears to be accidental; or if the cause of death is unexplained, the Procurator Fiscal (similar to a coroner in England and Wales) undertakes an independent inquiry of the circumstances surrounding the death, to determine whether criminal charges (in the case of homicide) or a Fatal Accident Inquiry is required. In some cases, the outcome of the investigation from the Procurator Fiscal can result in the GROS reclassifying the cause of death, but this is relatively rare.

3.2.3. International Classification of Diseases

Between 1980 and 1999, the GROS classified all registered deaths according to the ninth revision of the International Classification of Diseases (ICD-9). Since 2000, however, they have used the tenth revision of International Classification of Diseases and Health-Related Problems (ICD-10). Table 3-1 lists the ICD-9 and ICD10 codes corresponding with the main causes of death investigated in this study, and demonstrates that the structure of the two coding systems were considerably different. The ICD-10 saw a number of changes to the classification of diseases. First, the first character of each code is now alphabetical rather than numeric, as used in the ninth revision. The alphabetical code has extended the ability to classify diseases and health problems that have been recently identified (for example, the Severe Acute Respiratory Syndrome (SARS)), and to provide more detail regarding existing causes of death. The ICD-10 consists of over 8,000 unique codes, approximately 3,000 more codes than were used in ICD-9.

Second, some diseases or groups of conditions have been moved between ICD Chapters (groupings) to reflect the current ideas of aetiology and pathology. Third, the structure used to select the underlying cause of death has been altered significantly. Finally, the ICD-10 coding schema has been developed into an automated process (Griffiths and Rooney 2003; GROS 2001a) that has become an international standard.

Cause of Death	*ICD-9 Codes*	*ICD-10 Codes*
Stroke (cerebrovascular disease)	430 – 438	I60 – I69
Heart Disease (Ischaemic)	410 – 414	I20 – I25
Cancers (malignant neoplasms)	140 – 208	C00 – C97
Respiratory disease	460 – 519	J00 – J99
Accidents	E900 – E949	V01 – X59, Y85 – Y86
Suicides (and undetermined deaths)	E950 – E959, E980-989	X60 – X84, Y10-Y34, Y87.0

Table 3-1: ICD9 and ICD10 codes for the specific causes of death used in the analysis (Source: GROS 2003)

Some diseases or groups of diseases have been redistributed amongst one or more chapters of the ICD-10 and it may not be possible to make direct comparisons between deaths coded using ICD-9 and deaths coded using ICD-10. The GROS and the Office for National Statistics (ONS) carried out assessments of the comparisons between ICD-9 and ICD-10, known as a 'bridge coding' exercise. Bridge coding involved coding a sample of deaths using ICD-9 and ICD-10, comparing the results and identifying the equivalent codes or groups of codes in the two revisions that represent a particular cause of death. The results from this analysis were used to create comparability ratios, based on the number of deaths coded to a cause in ICD-10 equivalent to the number of deaths coded to the same cause using ICD-9. Causes of death that have a ratio greater than 1.00 represent cases where more deaths have been coded to ICD-10 than to the equivalent code in

ICD-9 (Griffiths and Rooney 2003). While many of the ratios are very close to 1.00, the ratios for some causes are considerably smaller. One of the major changes between ICD-9 and ICD-10 was the way in which the principal cause of death was specified. In the procedures for determining the cause of death, Rule 3 states that:

'If the condition selected by the general principle or by Rule 1 or Rule 2 is obviously a direct consequence of another reported condition, whether in Part I or Part II, select this primary condition.' (World Health Organisation, (1992-94), quoted in (GROS 2001a).

Thus, where a person that died of pneumonia would be coded accordingly under ICD-9, in ICD-10, if the death was due to another reported condition (for example, alcoholism), the death could be coded as such. In Scotland, the comparability ratio for pneumonia is 0.54, and reflects the very large fall in the number of deaths coded to this cause due to Rule 3 of the coding guidelines (GROS 2001a). While the coding of particular causes of death were affected by the introduction of ICD-10, broad causes of death, such as those outlined in Table 3-1, were not significantly affected.

3.2.4. 1981 Mortality Data

There were 189,654 deaths registered to a residential address between 01 January 1980 and 31 December 1982. Table 3-2 provides a summary of the main causes of death in Scotland, which will be analysed in this thesis. Half of the deaths reported for this period were from heart disease (54,108 deaths) and all cancers (41,439), which accounted for 28.53% and 21.85% of all deaths respectively. There were 27,058 deaths from stroke and a further 20,597 from respiratory disease, which together accounted for a further 25% of all deaths, while there were relatively few deaths as a result of accidents (6,539, 3.45%) and suicides (2,169 1.14%).

Although more women died than men during the period across all ages, considerably more men than women died prematurely. Furthermore, the distribution of premature deaths provides a notably different trend than for mortality among all ages. Heart disease (13,426) and cancers (13,757) accounted for 55.94% of premature mortality. Stroke (3,381) and respiratory disease (3,085) were dramatically reduced, accounting for 13.31% of all premature deaths, approximately 12% less than the proportion of all deaths. The percentage of premature deaths due to suicides (3.62%) and accidents (6.68%) were higher than the contribution of these causes to all deaths. This reflected the relatively high number of deaths among young adults from these causes. The 18,760 premature female deaths accounted for 38.61% of all premature deaths in 1981, demonstrating that there was an apparent gender gap in premature deaths. However, because the female deaths accounted for 50.56 of deaths in all ages, the apparent gender gap was diminished.

Cause of Death	*Total Population (%)*			*Under 65 Population (%)*		
	Male	Female	Total	Male	Female	Total
All Cause	93,752	95,898	189,650	29,832	18,760	48,592
Accidents	3,561 (3.80)	2,978 (3.11)	6,539 (3.45)	2,460 (8.25)	787 (4.20)	3,247 (6.68)
Cancers	21,692 (23.14)	19,747 (20.59)	41,439 (21.85)	7,110 (23.83)	6,647 (35.43)	13,757 (28.31)
Heart disease	29,979 (31.98)	24,129 (25.16)	54,108 (28.53)	9,948 (33.35)	3,478 (18.54)	13,426 (27.63)
Respiratory disease	10,732 (11.45)	9,865 (10.29)	20,597 (10.86)	1,881 (6.31)	1,204 (6.42)	3,085 (6.35)
Stroke	10,311 (11.00)	16,747 (17.46)	27,058 (14.27)	1,728 (5.79)	1,653 (8.81)	3,381 (6.96)
Suicides	1,367 (1.46)	802 (0.84)	2,169 (1.14)	1,142 (3.83)	618 (3.29)	1,760 (3.62)
All Other Causes	16,110 (17.18)	21,630 (22.56)	37,740 (19.90)	5,563 (18.65)	4,373 (23.31)	9,936 (20.45)

Table 3-2 1980-1982 mortality counts for the total population and the population aged below 65 years

3.2.5. 1991 Mortality Data

The pattern was much the same in the early 1990s. Between 01 January 1990 and 31 December 1992 180,604 deaths were registered in Scotland. The distribution of mortality for this period is provided in Table 3-3, which shows that heart disease (49,598 deaths) and cancers (44,576 deaths) accounted for over 50% of deaths across the total population. Deaths across all ages from respiratory disease (20,870) and stroke (23,475) together contributed a further 24.56% of deaths, while suicide (2,188) and accident related (4,877) deaths remained relatively few. The majority of premature deaths were due to cancer (12,743, 32.70%) and heart disease (9,532, 24.46%), while deaths from accidents, respiratory disease, stroke and suicide each accounted for between 4.75% and 5.78% of deaths.

For deaths among the total population, the proportion of deaths related to cancer, respiratory disease, and suicide, increased during the 1980s. Conversely, the proportion of deaths from accidents, heart disease, and stroke reduced. However, the proportional changes over time were marginal, ranging from -1.07% for heart disease to 2.83% for cancers. Furthermore, there was some variation in the trends for particular causes by gender, such as an increase in suicide among males and a decrease for females. Similarly, stroke mortality reduced among males but increased among females.

Proportional changes in premature mortality were also evident, with cancers exhibiting the largest increase (4.39%) and heart disease experiencing the largest reduction (3.17%) over the decade. The reductions in the proportion of respiratory disease and stroke exhibited for the total population resulted from reductions in these causes by males, while for females, deaths from these two causes increased between 1980-1982 and 1990-1992. Similarly, the increase in the proportion of premature suicide was explained by the increase of male suicide, as the proportion of female suicides reduced during the 1980s.

Cause of Death	*Total Population (%)*			*Under 65 Population (%)*		
	Male	Female	Total	Male	Female	Total
All Cause	86,757	93,847	180,604	23,799	15,168	38,967
Accidents	2,619 (3.02)	2,258 (2.41)	4,877 (2.70)	1,672 (7.03)	581 (3.83)	2,253 (5.78)
Cancers	22,812 (26.29)	21,764 (23.19)	44,576 (24.68)	6,490 (27.27)	6,253 (41.22)	12,743 (32.70)
Heart disease	26,354 (30.38)	23,244 (24.77)	49,598 (27.46)	6,926 (29.10)	2,606 (17.18)	9,532 (24.46)
Respiratory disease	9,874 (11.38)	10,996 (11.72)	20,870 (11.56)	1,296 (5.45)	1,009 (6.65)	2,305 (5.92)
Stroke	8,636 (9.95)	14,839 (15.81)	23,475 (13.00)	1,165 (4.90)	1,048 (6.91)	2,213 (5.68)
Suicides	1,613 (1.86)	575 (0.61)	2,188 (1.21)	1,404 (5.90)	445 (2.93)	1,849 (4.75)
All Other Causes	14,849 (17.12)	20,171 (21.49)	35,020 (19.39)	4,846 (20.36)	3,226 (21.27)	8,072 (20.71)

Table 3-3 1990-1992 mortality counts for the total population and the population aged below 65 years

3.2.6. 2001 Mortality Data

There were 173,921 deaths registered in Scotland between 01 January 1999 and 31 December 2001. As observed in the 1980s and 1990s, there were more female than male deaths when all deaths were investigated, but more males died prematurely than females. Table 3-4 shows that cancer (25.72%) and heart disease (21.38%) were the two leading causes of death among the total population, while respiratory disease and stroke together contribute a further 24%. There were 11,345 premature deaths due to cancer across the total population, accounting for 32.13% of all premature deaths. Among females, the 5,951 deaths from cancer amounted to 40.71% of deaths, while only 27% of premature male deaths were due to cancer. A further 20.47% of deaths among males and 10.82% of deaths among females were due to heart disease. Although respiratory disease and suicide accounted for similar proportions of premature mortality among the total population (6.14% and 6.35% respectively), they exhibited different trends by gender. Males experienced proportionally fewer premature deaths from respiratory disease than females, but proportionally more males than females committed suicide between 1999 and 2001.

Table 3-4 suggests that the 9% reduction in mortality across all ages between 1981 and 2001 can largely be accounted for by a 45% reduction in heart disease mortality from 54,108 in 1981 to 37,188 in 2001. The contribution of stroke (20,083 deaths) to total mortality in 2001 was 11.54%, approximately 2.5% lower than in 1981. However, improvements were not seen by all of the causes of death examined. Deaths attributable to respiratory disease *increased* by 4% from 20,597 in 1981 to 21,734 in 2001, while cancer mortality *increased* by 7% from 41,439 in 1980-1982 to 44,724 deaths in 1999-2001. Suicide mortality *increased* by 15% across the total population, although this increase masks the 24% reduction in the number of female suicides, and the 29% increase in suicide among males.

The reductions in premature mortality were more substantial than among the total population, whereby premature female mortality from heart disease and stroke reduced by 143% and 117% respectively between 1980-1982 and 1999-2001. Conversely, premature suicide increased by 33% among males and by 21% among the total population aged below 65 years. The 'all other causes' category was the only other group of deaths analysed to experience an increase between 1980-1982 and 1999-2001, whereby a 15% increase was evident for males, and a 3% increase was demonstrated among the total population.

Cause of Death	*Total Population (%)*			*Under 65 Population (%)*		
	Male	Female	Total	Male	Female	Total
All Cause	82,512	91,409	173,921	22,074	13,232	35,306
Accidents	2,154 (2.61)	1,982 (2.17)	4,136 (2.38)	1,254 (5.68)	408 (3.08)	1,662 (4.71)
Cancers	22,616 (27.41)	22,108 (24.19)	44,724 (25.72)	5,958 (26.99)	5387 (40.71)	11,345 (32.13)
Heart disease	19,629 (23.79)	17,559 (19.21)	37,188 (21.38)	4,519 (20.47)	1432 (10.82)	5,951 (16.86)
Respiratory disease	9,655 (11.70)	12,079 (13.21)	21,734 (12.50)	1,206 (5.46)	962 (7.27)	2,168 (6.14)
Stroke	7,428 (9.00)	12,655 (13.84)	20,083 (11.55)	885 (4.01)	762 (5.76)	1,647 (4.66)
Suicides	1,918 (2.32)	645 (0.71)	2,563 (1.47)	1,700 (7.70)	542 (4.10)	2,242 (6.35)
All Other Causes	19,112 (23.16)	24,381 (26.67)	43,493 (25.01)	6,552 (29.68)	3,739 (28.26)	10,291 (29.15)

Table 3-4 1999-2001 mortality counts for the total and under 65 population.

3.3. Standardised Mortality Ratios (SMRs)

Variations in the age and sex structure of the populations under examination must be considered before reliable comparisons between time periods and/or geographic areas can be made. This process, known as age-sex standardisation, can be calculated using two different approaches. First, the 'direct' method of standardisation is expressed as a rate of deaths for a particular population, such as 22 deaths per 100,000 residents, and is calculated by multiplying each age-specific mortality rate for one time period (or area) by the proportion of the population in that age group in the 'standard' population, and subsequently adding the results for all age specific groups. The direct method depends on the age-specific rates for the observed population, and is therefore not appropriate when there are only a few deaths observed (Bland 1995).

The second approach, known as the 'indirect' method, is more appropriate when the number of deaths in one or more age groups is small. The results from the standardisation are represented as the ratio of observed deaths to the expected deaths, which are calculated differently to the direct method. Death rates for the standard population are calculated by dividing the total number of deaths in each age group by the total population in the same age group. Next, the age and sex specific population for each observation (e.g. geographic area) is multiplied by the age-specific death rate to calculate the age and sex specific expected number of deaths, which are consequently added together to determine the total number of expected deaths for each observation. Equation 3-1a shows that the SMR is calculated by dividing the number of observed deaths (O) by the number of expected deaths (E) and multiplying by 100 (Bland 1995). Confidence intervals (95%) can also be calculated following the formula outlined in Equation 3-1b.

$$\text{a)}\quad SMR = \frac{O}{E} \times 100$$

$$\text{b)}\quad Confidence\ \ Interval = SMR \pm 1.96 \times 100 \times \frac{\sqrt{O}}{E}$$

Equation 3-1 The formula for used to calculate standardised mortality ratios (SMRs) and 95% confidence intervals (Source: Bland 1995)

The 'standard' population used in the calculation of SMRs or death rates can be any population, such as the population structure from a particular census period, although the World Health Organisation (WHO) has developed a standard 'million' population for the World and Europe that is commonly used for mortality rates based on the direct method.

In this study, the indirect method of standardisation has been used to express mortality trends. Furthermore, the standard population is derived from the age-sex structure of the Scottish population from the census. For example, SMRs for 1980-1982 have been calculated using the total population from the 1981 census. Similarly, SMRs for 1990-1992 were calculated using the 1991 census population and the SMRs for 1999-2001 were based on the 2001 population structure. When the age-specific death rates and population data from the same period (e.g. 1980-1982 rates, 1981 population) are used to calculate the expected number of deaths, the total number of expected deaths in a given age-sex group should be the same as the total number of observed deaths in the same age-sex category, and are referred to as *period-specific* SMRs in this study. Alternatively, there are some instances when the age and sex specific death rates from 1981 are applied to the 2001 population and mortality data to create an SMR for a later time period, such as the 1999-2001 data, and are referred to as *consistent* SMRs. Consistent SMRs enable temporal comparisons in mortality to be examined, but the total number of expected deaths does not typically equal the total number of observed deaths. Ideally there should be less observed deaths than expected, resulting in lower SMRs than reported for the period specific SMRs, reflecting the fact that mortality has improved since 1981.

3.4. Scottish Census Geography, 1981-2001

The population and other social data used throughout this study are derived from the small areas created for the dissemination of the 1981, 1991 and 2001 censuses. While the census data provide a reliable source of demographic characteristics required for the calculation of SMRs, the configuration of the census boundaries are susceptible to changes over time. Chapter Four describes a method for constructing consistent geographical areas for Scotland, which are necessary to calculate reliable SMRs between 1980-1982, 1990-1992 and 1999-2001. Here, the characteristics of the small area census geography in Scotland for 1981, 1991 and 2001 are described. Furthermore, this Section demonstrates that while every effort was made to ensure that changes to the census boundaries over time were kept to a minimum, some changes were inevitable.

In England and Wales, the smallest spatial unit used for the dissemination of census data was the Enumeration District (ED) in 1981 and 1991, and the Output Area in 2001. The Office of Population and Census Statistics (OPCS, now Office for National Statistics, ONS) designed the EDs for 1981 and 1991 for the efficient collection of the census returns by one enumerator, and these units were also used for the dissemination of the census results. In the main, EDs contained approximately 500 residents in urban areas, and an average of 150 residents in rural areas. For the 2001 census, EDs were used for the collection of census scripts, but small area statistics were reported for Output Areas (OAs) that were constructed from postcode units.

Scottish census boundaries have been built from postcodes since 1981. The GROS also manage the decennial census in Scotland and favoured postcodes as a base for census geography because postcodes were familiar to census users, they were maintained continuously by the Post Office (now Royal Mail), and lookup tables and directories were regularly published (Denham and Rhind 1983). In addition, the census data could be linked into other datasets that record postcode information, such as health and other administrative data.

3.4.1. The 1981 Census

The smallest 1981 EDs were created by the GROS by drawing unit postcode boundaries onto 1:10,000 and 1:2,500 scale base maps, by hand. Acetates of the 1981 postcode boundaries were overlain upon 1:10,000 Ordnance Survey (OS) maps in rural areas and 1:2,500 OS maps in urban areas. In addition staff at the GROS were provided with unit postcode population estimates, derived from the household delivery point information included in the Central Postcode Directory (CPD) (Denham and Rhind 1983).

With a target population of 150 households maximum, staff at the GROS manually constructed the ED zones by aggregating the unit postcodes. Whilst there was a household threshold to be adhered to, the size of each ED needed to constitute a manageable workload for the enumerator collecting the census returns. Therefore, some EDs included more households, particularly in urban places, while other EDs contained only three or four houses. In these cases, only the number of houses was made available to users of the census. The other household-related data were 'suppressed' and not reported for these particular EDs, but were amalgamated with an adjacent ED. Similarly, if the total population was less than 25 persons, only the number of males, the number of females and the total population were reported in the SAS for these EDs, and the remaining individual-related counts were amalgamated with the same adjacent ED used for suppressed household information. Note that a unit postcode was only split when it crossed a boundary of one of the higher geographies such as regions, districts, or health board areas. These EDs were used for the collection of census forms and the production of small area output.

The GROS produced 17,767 EDs for Scotland in 1981. Of these, there were 16,508 'unrestricted' EDs, which were zones that contained more than either 8 households and/or more than 25 people. Data for 'unrestricted' zones were made readily available to users, however their boundaries were not digitised for technological and financial reasons. Rather, a grid reference for each zone was provided by the GROS, which enabled demographic data to be mapped as points, or mapped upon boundaries in the form of Thiessen polygons. The remaining 1,259 EDs were 'restricted' and were either zones that were suppressed because they had had low populations, or were 'special EDs' – institutions such as hospitals and army barracks that had a population greater than 100 people – whose returns were collected by the Chief Returning Officer. In addition, there were 56 zones (one for each district) that reported the census returns of residents and visitors that were at sea, or were docked in port.

Although the EDs were the main geography output for small area statistics for the 1981 census, GROS developed a series of higher geographies for reporting demographic summaries, which are shown in Table 3-5. The eight-character zone labelling convention used by GROS meant that aggregation from EDs to higher geographies was relatively easy (see Table 3-5, column 3). The highest aggregation (apart from the national level) was the region, represented by the first two characters of the label. The first four characters depicted the local government district to which the ED belonged, while the first six characters identified the pseudo postcode sector. In addition to these higher geographies, ED data could be aggregated to other geographies such as parliamentary constituencies, civil parishes, standard statistical regions, health districts, towns, conurbations, as well as urban/rural areas (Denham and Rhind 1983).

Area Level	*Number of Zones*	*Zone Label*
ED	17,767	5601AA01
Pseudo Postcode Sector	1154	5601AA
Local Government District	56	5601
Region	10	56
Scotland	1	N/a

Table 3-5 A summary of the official census aggregations for 1981

3.4.2. The 1991 Census

In 1991, two small area census geographies were created by GROS. One was a new set of EDs, which was constructed solely for the collection of the census returns and was not published. The 1991 EDs were based on the 1981 EDs and were subject to only minor changes, and were not published for general use by external users. The second set of boundaries developed comprised of smaller areas, developed for the dissemination of census results at a more detailed level, and were known as Output Areas (OAs).

Once again, unit postcodes were used as the foundations from which the 1991 Scottish census geography was built. There were 38,254 OAs in Scotland, of which 38,098 zones were 'unrestricted' and whose boundaries were digitised. The remaining 156 OAs were 'restricted' and were typically institutions such as hospitals or military bases where census returns were collected by the Chief Returning Officer, rather than general enumerators. In addition, the restricted OAs did not have geographic boundaries, but their data were allocated to an adjacent OA. In 1991, there was only one 'shipping' OA, which counted information for all residents and visitors that were aboard ships located within Scottish waters on Census night.

The GROS used the same zone labelling convention that was used for 1981 EDs for OAs, except that some OAs had an alphabetical suffix added. Those 1991 OAs that had an alphabetical suffix identified those 1981 EDs that had large populations in 1991, and had therefore been neatly split into a series of 1991 OAs with smaller populations. For example, 1991 OAs 5601AB03A, 5601AB03B and 5601AB03C were subdivisions of the 1981 ED 5601AB03. In most cases, the 1991 OAs were neat subdivisions of 1981 EDs, and only 2,869 OAs were identical to a 1981 ED. The majority of 1991 OAs resulted from splitting a 1981 ED into two (6,015) or three (6,109) distinct OAs. The 1981 ED 6018AA01 was split the most, from which 22 separate 1991 OAs were created, because of significant population growth in that area.

Despite the fact that there were significantly more 1991 OAs than 1981 EDs, the confidentiality requirements introduced for the 1991 census meant that a relatively small number of 1981 EDs were too small to be retained as distinct 1991 OAs and had to be increased in size. Thus, the regulations stated that no 1991 OA could contain less than 50 people, or 16 households. In cases where the 1991 populations of postcodes belonging to a 1981 ED did not meet either or both of these rules in 1991, the population was increased in size by allocating one or more adjacent postcodes, which originally belonged to a neighbouring 1981 ED. In these cases, the boundaries of 1991 OAs did not fit neatly within the boundaries of the 1981 EDs, as a 1991 OA could overlap with two or more 1981 EDs. Because of this, there were 1,670 1981 EDs that could not be identified from the 1991 OA boundary file.

A lookup table was created by GROS that identified each of these cases, linking all postcodes that were allocated to a different 1991 OA than might have been expected, with the reasons why. Most of these anomalies occurred because there were too few persons or too few households for the 1981 ED to become a distinct 1991 OA. Other reasons included postcodes that were in special 1981 EDs that became ordinary (unrestricted) 1991 OAs, deletion of postcodes between censuses, administrative boundary changes of larger zones, such as wards, and zone re-labelling.

Because the 1991 OAs adopted the 1981 ED zone labelling conventions, they were designed to aggregate to the same higher aggregations as the 1981 EDs (see Table 3-6). One major difference between 1981 and 1991 was that in 1981 Orkney, Shetland and the Western Isles were one zone ('Island Regions'). However, in 1991 each group of islands became their own region, increasing the number of regions from 10 to 12. In addition, the number of Pseudo Postcode Sectors also changed between 1981 and 1991, in response to changes in the population distribution. In addition to boundary files GROS released population-weighted grid references for each unrestricted OA, which can be used in point-in-polygon queries to aggregate OAs to other higher geographies such as parliamentary constituencies and health boards.

Level	*Number of Areas*	*Average Number of Households*	*Average Population*	*Zone Code*	*Example and Description*	
Region	12	168,337	416,547	2 Numbers	60	Grampian Region
District	56	36,072	89,260	4 Numbers	6018	Kincardine & Deeside District
Pseudo Postcode Sector	1,003	2,107	5,318	4 Numbers + 2 Letters	6018AA	Postcode Sector "AB1 4"
Output Area	38,098	53	131	4 Numbers + 2 Letters + either: 2 Numbers or 2 Numbers + 1 Letter	6018AA01A	

Table 3-6 The hierarchical structure of the 1991 census

3.4.3. The 2001 Census

In 2001, the number of OAs increased from 38,254 in 1991 to 42,604, even though the GROS made attempts to create continuity between the two censuses. The increase in OAs was due to an increase in the number of postcodes created in Scotland by the Royal Mail. New postcodes are normally created for new residential estates, which would suggest population growth. However, during the past decade the increase of postcodes has primarily been in response to a growing proportion of single-occupant housing in a country that has been experiencing population decline over the past few decades.

The Office for National Statistics (ONS) oversees the census process in England and Wales. In previous censuses, Enumeration Districts (EDs) were constructed by the ONS for the collection of census returns and were also used as the lowest level of census output. EDs often followed the underlying topography, such as major roads, water features and railway lines, and were criticised for not always matching clear breaks in the demographic structure of areas (Morphet 1993). While attention was paid to minimal population thresholds, the EDs were constructed for each census with little attention paid to consistency through time. However, for the 2001 census, the ONS chose to adopt the postcode-based approach used by GROS, thus abolishing EDs (for the dissemination of census data) and constructing OAs based on postcode geography. This approach has been welcomed by academics because it enables postcode-level data to be easily associated with the 2001 census results.

The new approach to constructing census output areas also prompted the creation of a new zone labelling convention. For 2001, each OA in Great Britain has a ten-character label, for example "60QA000001". The first two characters are always numeric, and distinguish between England, Wales, Northern Ireland and Scotland. Thus, each of the 42,604 Scottish OAs begin with "60". The third and fourth characters are both alphabetical, and represent the Council Area within which the OA is located. The remaining six characters are all numeric, and represent individual OA identifiers, hence, the 2001 OAs only nest neatly within the country and Council Areas (GROS 2004b).

An important development between 1991 and 2001 was the abolition of Districts and the creation of Council Areas. Council Areas were created following the UK-wide restructuring of local governments, in which the old two-tiered system (56 Districts) was replaced by a single tiered system of 32 Council Areas (Wilson and Rees 1999). Unfortunately, the restructuring was not simply a merger of two previous districts, and therefore it is not possible to aggregate Council Areas neatly back to Districts, thus prohibiting the comparison of district-level social characteristics through time.

The GROS also abolished the 'shipping' and 'special' OAs for the 2001 census, instead making distinctions between counts made for the 'residential' population and those living in 'communal establishments' within each OA. Communal establishments include hospitals, military bases, residential homes, university halls of residence, hostels and other locations in which a high number of people may reside. However, the responses from residents living in tower blocks would be counted as 'residential addresses' (GROS 2004b).

For 2001, one postcode from every OA was designated as a 'master postcode'. Point in polygon queries were used to allocate this postcode to higher geographies, and the OA adopted all of the characteristics of the master postcode. Of the higher geographies that have been made available for 2001, OAs only nest neatly within the Council Area. The aggregation of OAs to Sectors and Electoral Wards are approximations only, and no data have been made available for 'true' Postcode Sectors or Electoral Wards because these configurations cross Council Area boundaries (GROS 2004b).

Census Postcode Sectors were based on Postcode Sectors developed by Royal Mail, but were modified to ensure that they nest within Council Areas, while also conforming to confidentiality constraints. In 2001, there were two different types of census Postcode Sectors: Census Area Statistics (CAS) and Standard Tables (ST). There were 1,010 CAS Sectors in 2001, which were required to have at least 50 people or 20 households, whereas the 859 ST Sectors had minimum thresholds of 1,000 people and 400 households. Merging two or more adjacent CAS Sectors within the same Council Area was sometimes necessary to ensure that the population thresholds were met when the ST Sectors were created. The ST Sector labels identify mergers by listing the affected Sectors, and separating them by a semi-colon (;). For example, two CAS Sectors were merged to create the ST Sector 'AB51 7; AB32 7'. In addition, CAS or ST Sector labels that end in 'part' (for example 'AB21 0 (part); AB15 8 (part)') identify those Sectors that crossed Councils Area boundaries (GROS 2004b).

Similarly, the 'master postcode' was used to allocate OAs to two different sets of Wards in 2001: CAS Wards and ST Wards. There were 1,222 CAS Wards and they had the same population and household constraints as the CAS Sectors, although on average, the population of Sectors is bigger. The same criteria outlined above for the creation of ST Sectors were used in the development of the 1,176 ST Wards (GROS 2004b).

One of the problems associated with the use of a master postcode in the allocation of the 2001 OAs to higher geographies was that non-contiguous or 'multi-extent' zones have been created (Figure 3-1). The 2001 OA centroids (i.e. the grid references of the master postcodes) have been overlain upon the 2001 electoral ward boundaries in Figure 3-1A, which results in three 2001 OA centroids ('a' 'd' 'e') being allocated to the 2001 Ward. However, when the OA boundaries were examined, it became apparent that two OAs ('a' and 'e'), were non-contiguous. Therefore, when the OA boundaries were dissolved to create the CAS Ward boundaries, two polygons with the same zone label (X) were created, thus producing a non-contiguous zone (Figure 3-1B).

Although Figure 3-1 refers to CAS Wards, the same problems occurred during the creation of the CAS Sectors, ST Sectors and ST Wards. The presence of non-contiguous areas is more prevalent in Wards than in Sectors, with 14 % of CAS Wards and 13.4% of ST Wards being comprised of non-contiguous areas. This was contrasted with 5.8% of CAS Sectors and 6.9% of ST Sectors having non-contiguous areas (GROS 2004b).

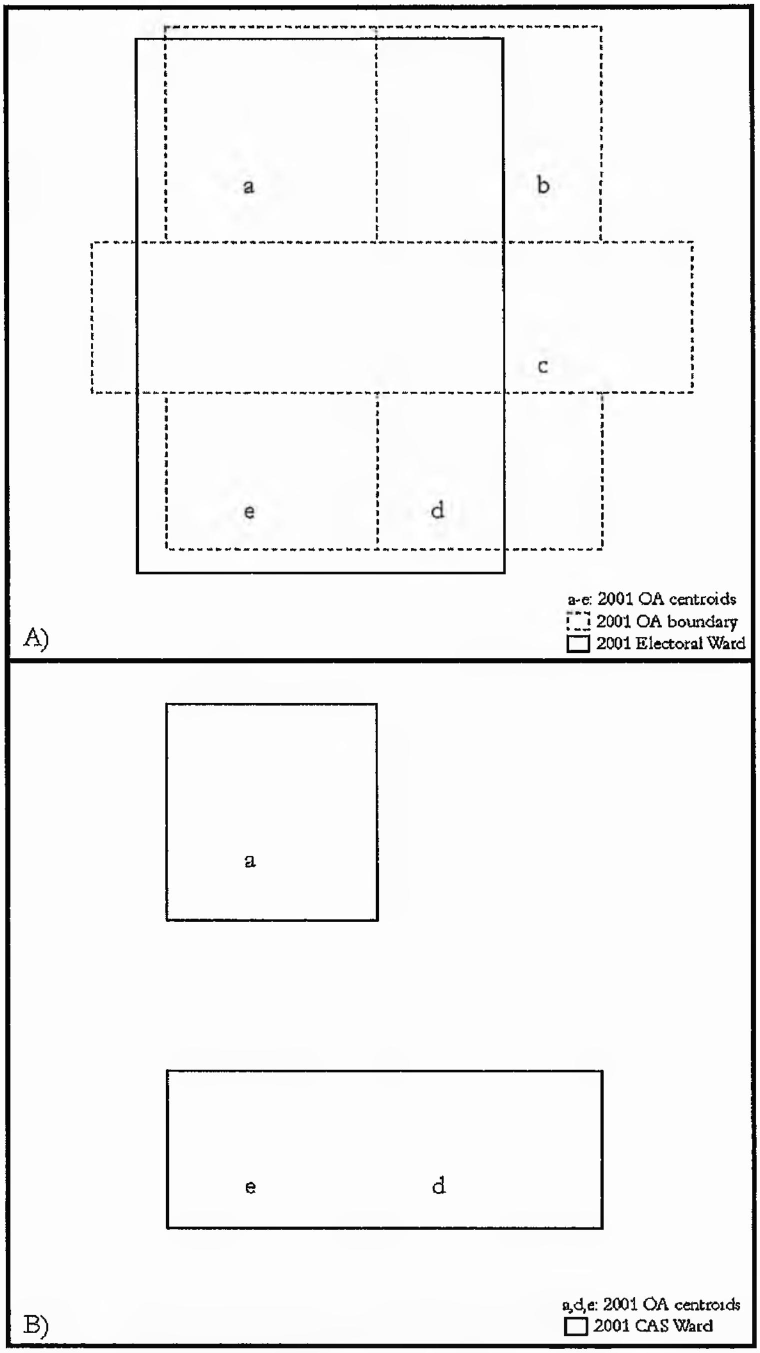

Figure 3-1 An example of how multi-extent wards were created in 2001

This Section has introduced the Scottish census geography between 1981 and 2001, and has shown that although the GROS made attempts to maintain consistency in the configuration of census boundaries and census questions, some changes were inevitable. Boundary changes largely resulted from the changing demographics of small areas in Scotland. For reliable comparisons of mortality and social data over time to be made, the underlying geography must be standardised, in the same way that mortality ratios are standardised for variations in the age and sex distributions of a given population. Chapter Four therefore describes a method for constructing consistent geographical areas to facilitate the analysis of mortality and social data from 1981, 1991 and 2001. It should be noted that the method for constructing a consistent geography described in Chapter Four has only been possible because postcodes have provided the foundations for the construction of census boundaries since 1981 in Scotland.

In this study, the census data from 1981, 1991 and 2001 are used in the construction of SMRs. In addition, census data are used throughout the remainder of the study to represent the social structure of Britain. In Chapters Five, Six, and Seven, four variables are used to create a composite index of deprivation, which is discussed in the following Section. Furthermore, a selection of social variables shown in the literature to be associated with elevated suicide risk are described in Chapter Seven prior to their use to model the occurrence of suicide within small areas.

3.5. Constructing the Carstairs Index of Deprivation

A number of deprivation indices exist (e.g. Townsend 1987; Jarman 1983, Social Disadvantage Research Centre 2003), however the deprivation index by Carstairs and Morris (1991); referred to hereafter as the 'Carstairs index', was chosen for use throughout this thesis for a number of reasons. First, the Carstairs index was designed for Scotland and has subsequently been well tested there (e.g. Carstairs and Morris 1989, 1991; Black *et al*, 1994; McLoone and Boddy 1994; Carstairs 1995; Hadjichristodoulou *et al*, 2001; McLoone 2003; Ahmed *et al*, 2004). Second, the variables used for the construction of the Carstairs index were available from the 1981, 1991 and 2001 censuses. Third, the Scottish Indices of Deprivation were not released at the time the analysis started and would not have been suitable because it was only specific to 2001 and not available for 1981 or 1991.

The Carstairs index was originally developed to assess geographic variations in relative material and social deprivation in Scotland at the Pseudo Postcode Sector (PPS) level, which are similar in size to census wards in England and Wales. It consisted of four standardised variables: unemployment; overcrowding; (lack of) car ownership; and low social class. Although the index was originally constructed using data for individuals (rather than households) from the 1981 census, Carstairs and Morris (1991) used the 1971 census to justify their choice of variables. Despite only having 11 % of EDs in Great Britain in 1971 Scotland had 53.6% of all EDs in Great Britain with overcrowded households, 34.5% with men unemployed, 35.9% with no car, and 21.9% in the lowest social group (Carstairs and Morris 1991, p.5).

In this study, the Carstairs index has been developed from the 1981, 1991 and 2001 Censuses. However, Table 3-7 shows that there were some differences in the way the variables were defined between 1981 and 2001. The most significant change was the definition of the low social class component of the index in 2001, which resulted from a change in the way social class was defined by the Office of National Statistics. Some of the other changes were more subtle, for example the unemployment variable referring to male residents aged 16 years and over in 1981 and 1991, but referring to males aged 16-74 in 2001. The Carstairs index ranged from –6.34 (least relative deprivation) to 14.12 (most relative deprivation) for 1981. In 1991, the index ranged between –5.28 and 16.06, while the 2001 census produced an index ranging from –5.94 in the least deprived areas to 17.47 in the most deprived area. Carstairs and Morris (1991) aggregated their index into 7 categories known as DEPCAT classes. The proportion of the Scottish population allocated to each DEPCAT was similar to the distribution of social class in Scotland. In this study, the continuous deprivation scores for each census were aggregated into population-weighted quintiles, each of which contained a population of approximately one million.

The distribution of the population-weighted quintiles for 1981, 1991, and 2001 are shown in Figure 3-2, Figure 3-3, and Figure 3-4 respectively. The Figures show many of the most deprived quintiles were located in the Greater Glasgow area during each decade, although the most deprived quintiles were also scattered throughout other parts of Scotland. Similarly, while the majority of the least deprived areas appeared to be located in rural areas, the least deprived quintiles were also located in urban and suburban areas. Interestingly, whereas Glasgow contained a concentration of the most deprived quintiles for the duration of the study period, the neighbouring areas appeared to worsen between 1981 and 1991, but improved again between 1991 and 2001. The Highlands exhibited a similar pattern, in which some areas belonged to the less deprived quintiles in 1981, but deteriorated in the 1980s and were allocated to the most deprived quintile for the 1991 census; an improved to be relatively average in 2001.

Variable	*Definitions for 1981, 1991 and 2001*
Unemployment	1981/1991: Unemployed male residents aged 16 and over as a proportion of all economically active male residents aged 16 and over. 2001: Unemployed male residents aged 16-74 as a proportion of all economically active male residents aged 16-74.
Overcrowding	1981/1991: Households with 1 and more persons per room as a proportion of all households. 2001: Households with 1 and more persons per room as a proportion of all households.
Non car ownership	1981/1991: All people in households with no car as a proportion of all people in households. 2001: All people in households with no car as a proportion of all people in households.
Low social class	1981/1991: Economically active head of household in social class IV or V as a proportion of all economically active people. 2001: Persons aged 16-74 in Social Class IV or V (estimated by using NS-SEC groups 11.2, 12.2, 12.4, 12.5, 12.7, 13.1, 13.2, 13.4 and 13.5) as a proportion of all persons aged 16-74.

Table 3-7 The Census-derived variables used to calculate the Carstairs Index of Deprivation for 1981, 1991 and 2001

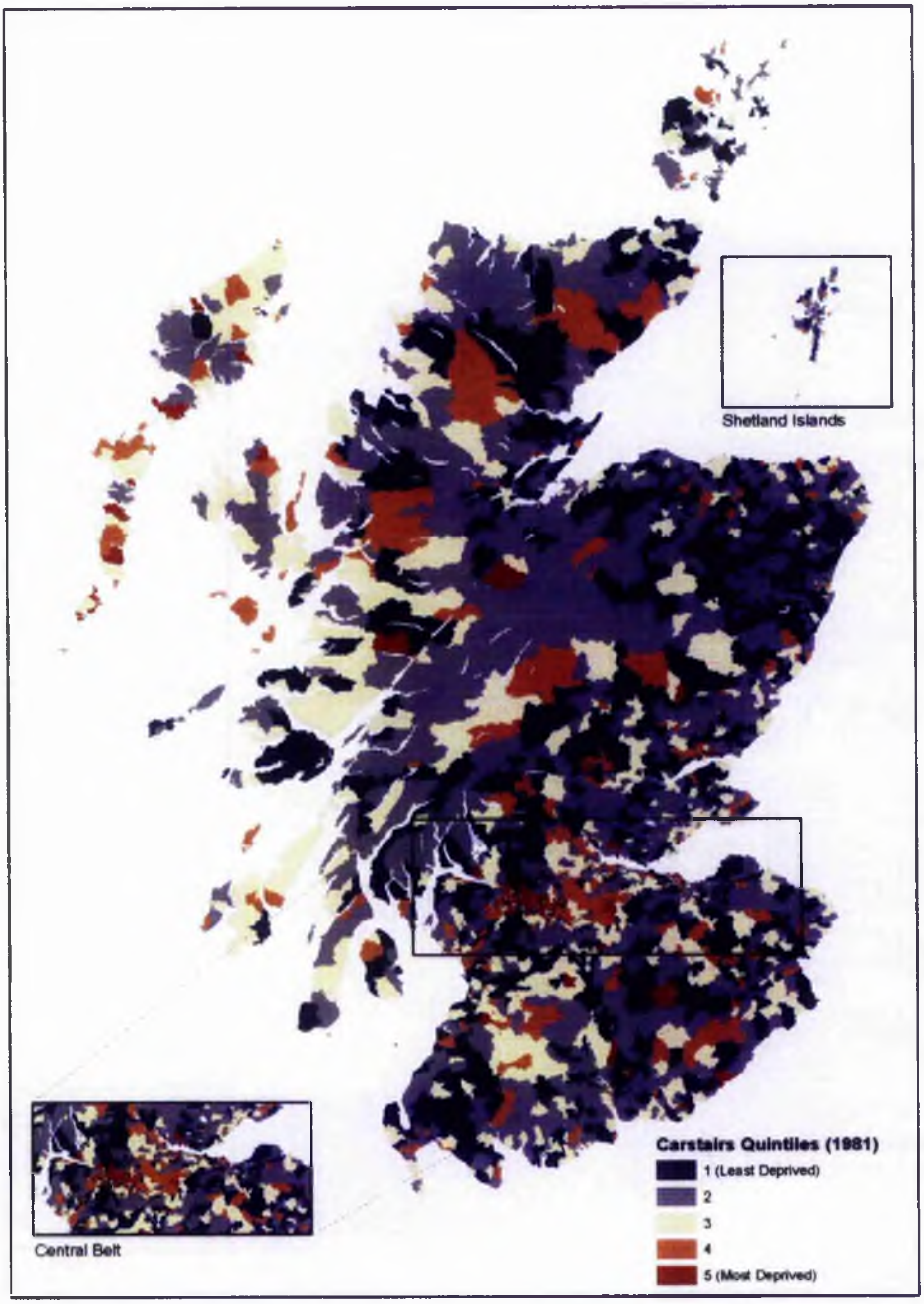

Figure 3-1 The Carstairs index of deprivation, 1981

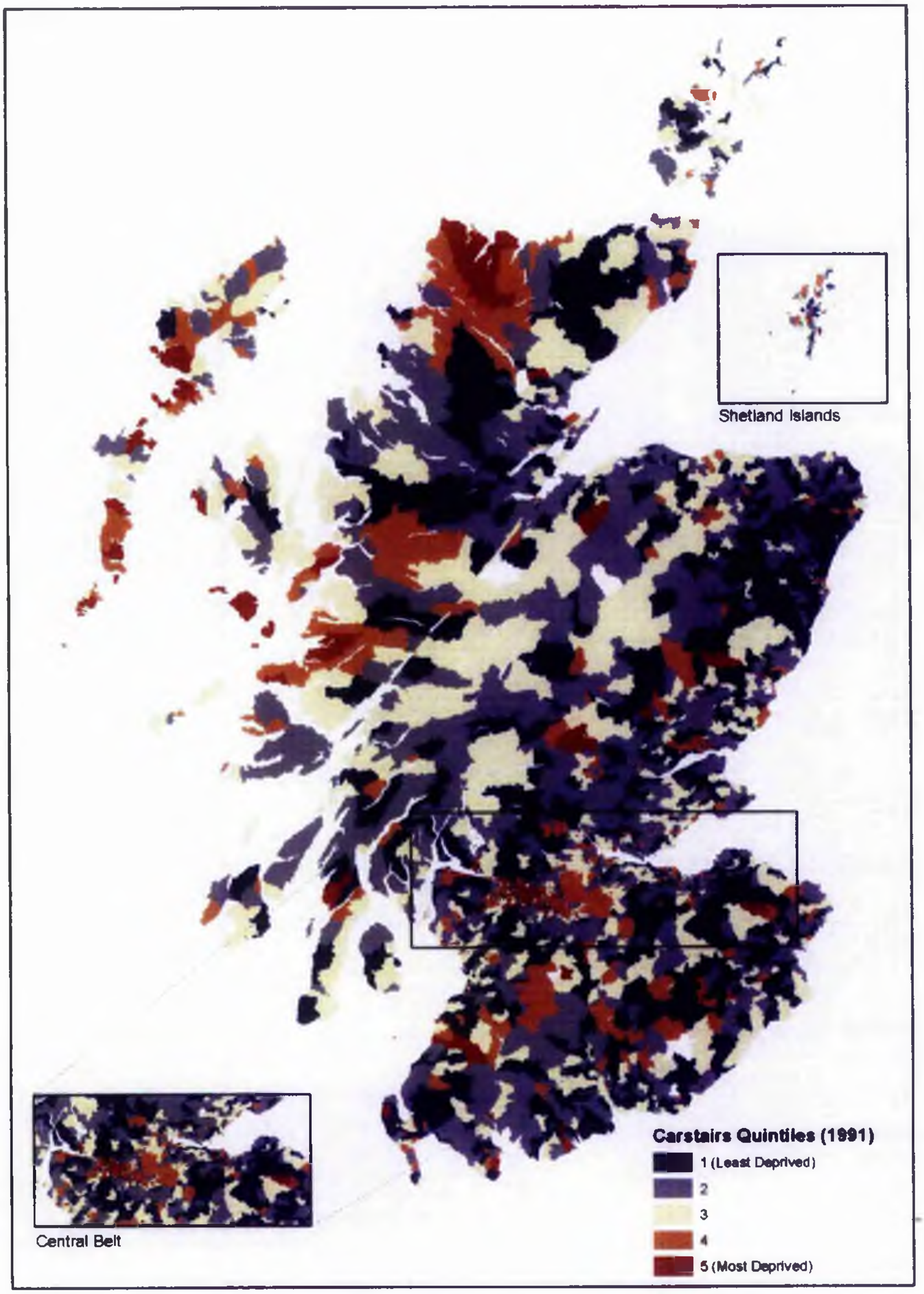

Figure 3-2 The Carstairs index of deprivation, 1991

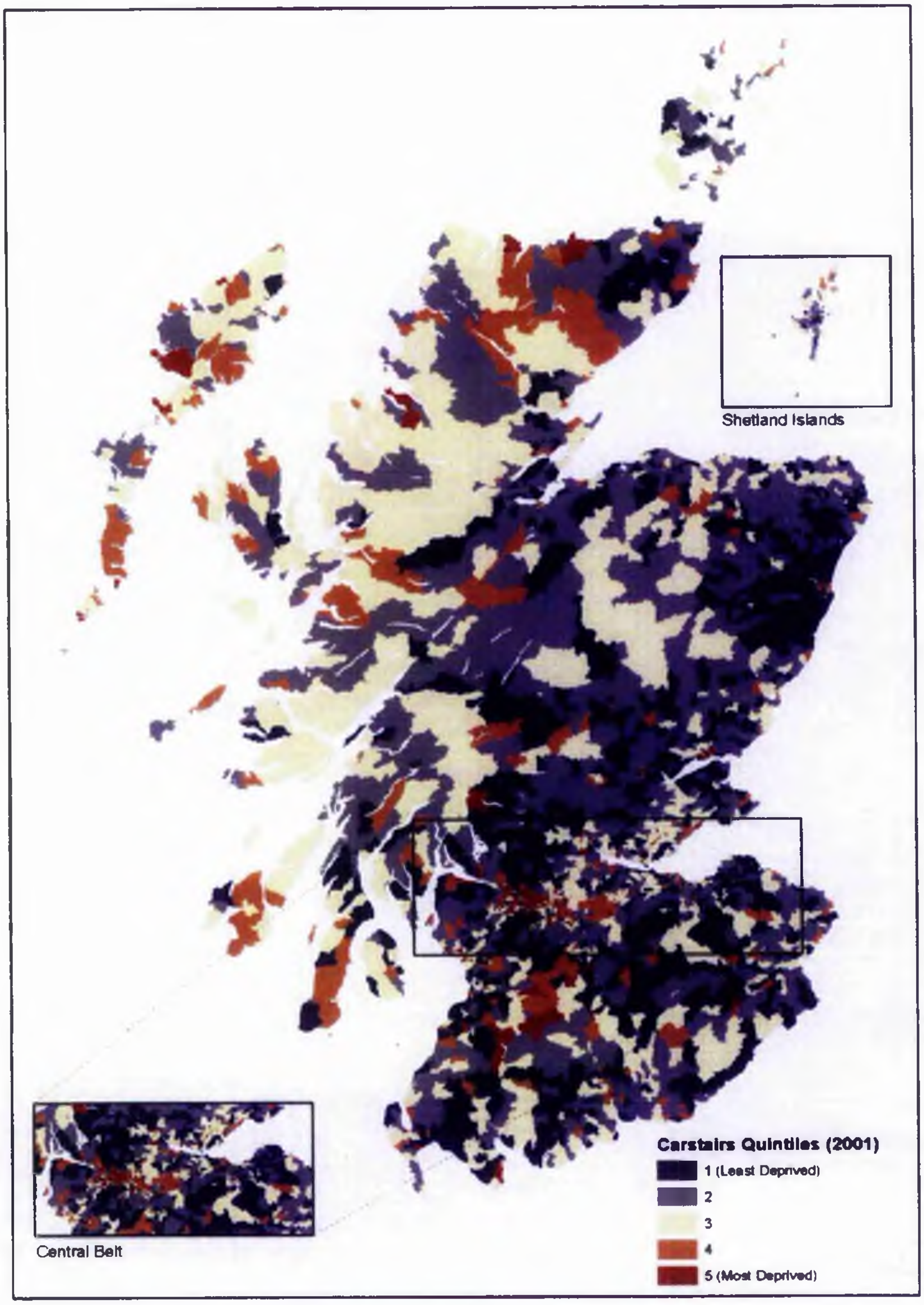

Figure 3-3 The Carstairs index of deprivation, 2001

3.6. Conclusions

This chapter has introduced the data that are used throughout this study. Section 3.2 considered the trends in mortality in Scotland between 1980-1982 and 1999-2001, and showed that although the total number of deaths decreased during the study period, some diseases decreased more than others, while suicide increased over time. Throughout Section 3.2 the proportion of deaths attributable to accidents, cancer, heart disease, respiratory disease, stroke, suicide and all other causes combined were reported for each time period. However, comparisons based on raw data are not reliable, as the demography of the underlying population changes over time. Therefore, in this study the mortality data will be compared using Standardised Mortality Ratios (SMRs), using the methods outlined in Section 3.3.

Section 3.4 introduced the Scottish census geography used during the study period, and demonstrated that the boundaries for each census (1981, 1991, and 2001) changed substantially, mainly because the EDs in 1981 and the OAs in 1991 and 2001 were developed for the purpose of efficient collection of scripts, rather than detailed geographic analysis. Changing confidentiality thresholds also meant that the configuration of the small area census areas needed to be altered. Therefore, in order to make reliable comparisons between small areas over time, a method for creating a consistent geography is required.

In the present study, the Scottish population by age and sex for each time period is used as the denominator in the calculation of SMRs, and the social composition of Scotland is represented through the calculation of the Carstairs Index of Deprivation (Carstairs and Morris 1991).

Note that some analyses in this study do not use the Carstairs index to define social groups, while others do not use SMRs to compare mortality over space and/or time. When new or novel approaches to examining mortality have been used, the data and methods used for the specific piece of analysis are discussed within the Chapter concerned. For example, Chapter Seven uses a Poisson-based model to predict suicide risk across small areas, and is preceded by a description of Poisson modelling. Similarly, in the modelling of suicide, a selection of census variables is used to control for the social composition of each area, which are also introduced prior to the analysis being conducted.

Methods are available to reliably compare changes in mortality over time through the calculation of SMRs and to represent social conditions for each census, by calculating the Carstairs Index of Deprivation. There are also many techniques available to create a 'consistent geography' in which data from two or more different sources are transformed into a common boundary configuration (e.g. Bracken and Martin 1995; Martin *et al.* 2002; Norman *et al.* 2003). However, the existing techniques rely upon a population estimation methodology, which introduces error. Furthermore the degree of error that is introduced can vary depending on the nature of the underlying geography being transformed.

The following Chapter describes an alternative method to creating a consistent geography, in which data from 1981 EDs and OAs from the 1991 and 2001 censuses are transformed without the use of population estimation. The resulting zones, known as Consistent Areas Through Time (CATTs), are then used as the geographical base upon which inequalities in mortality are examined in Chapters Five, Six and Seven.

4. A Method for the Creation of 'Consistent Areas Through Time' (CATTs)

4.1. Introduction

This Chapter describes a new method for constructing consistent geographical areas for Scotland, using data from the 1981, 1991 and 2001 censuses. These areas have the same boundaries for each census, so that direct comparisons over time are possible. There have been many studies that investigate changes in population health and socio-demographics through time (e.g. Boyle *et al.* 2004a, 2004b; Dorling 1997; Mitchell *et al,* 2000; Shaw *et al.* 1998, 1999). However, comparative census analysis of socio-demographic change has traditionally been restricted to large spatial units, such as standard regions. This is because the most detailed tabulations are usually provided for larger areas (Norris and Mounsey 1983) and also because administrative and electoral Districts are less susceptible to dramatic boundary changes between censuses than smaller areas such as Output Areas (OAs), Enumeration Districts (EDs), Wards or Pseudo Postcode Sectors. While the use of higher geographies such as Council Areas and Parliamentary Constituencies may be useful for reporting changing demographic, socio-economic and health patterns through time, they can mask important local variations.

There are a number of problems with local level analyses that span three population censuses. First, the lowest geography for which census data can be output is susceptible to change for each census as confidentiality constraints are adjusted. For example, in the 1981 Scottish census, each area had to contain at least 25 residents, but in 1991 this threshold increased to 50 residents or 16 households for confidentiality reasons. Second, even if the confidentiality thresholds were unaltered, changing population dynamics may require that census boundaries need to be altered, and therefore it is possible for some houses to be located in up to three different census zones during this study period. Third, while data obtained from population censuses provide geographers with a powerful dataset, the boundaries designed by most governments are designed with efficient enumeration, not geographical analysis, in mind.

As mentioned in Section 3.4, The General Register Office for Scotland (GROS) is responsible for the preparation, collection and dissemination of Scotland's census. In 1981, one set of Enumeration Districts (EDs) was constructed which were used both for the collection of census surveys and for the dissemination of census data. Unlike the EDs in England and Wales, the 17,767 Scottish EDs were based on postcode units. For the 1991 census the GROS produced a set of EDs for the collection of the census, but data were disseminated using 38,254 Output Areas (OAs). They were also based on postcode units and, although the 1991 OAs were generally smaller than the 1981 EDs, they were designed, in the main, to be nested within them. Similarly, for the 2001 Census, 42,604 OAs have been used for the dissemination of the data. Once again, these were based on postcodes and the GROS aimed to make sure that the 2001 OA boundaries would fit within the boundaries of other administrative units.

Table 4-1 provides a ranking of areas that the 2001 OAs were designed to nest within, which was agreed through a consultation exercise. Each 2001 OA was assigned a 'master' postcode, which was used by the GROS to allocate the OAs to all of the 'higher' geographies. With the exception of Council Areas (into which OAs fit exactly), all higher geographies are best-fit approximations (GROS 2004b). Because less weighting was given to the structure of the 1991 OAs, the relationship between 1991 OAs and 2001 OAs was far from perfect. Consequently, it is not simple to analyse change through time at the local level for consistent geographical areas.

Ranking	Aggregation
1 (most important)	2001 Council Area
2	2001 Locality
3	1991 OA
4	2001 Postcode Sector
5 (least important)	2001 Electoral Ward

Table 4-1 the hierarchy of zones that 2001 OAs were designed to nest as well as possible within. (Source: GROS 2004b)

A number of methods exist that enable two or more geographies to be combined into a common geography (Bracken and Martin 1995; Flowerdew and Green 1994; Goodchild *et al.* 1993; Martin *et al.* 2002; Norman *et al.* 2003; Simpson 2002). Most of these approaches convert data from two or more 'source' geographies into a new 'target' geography. The conversion process normally involves the proportional redistribution of data from the source geographies to the target geography, based on a pre-defined weighting scheme. Consequently, these techniques introduce error, which varies depending on the technique that is used (Norman *et al.* 2003).

Following a review of the literature concerning the construction of consistent geographies, the remainder of this Chapter describes the construction of CATTs as a three-step process. First, the 1981 EDs and 1991 OAs are integrated to create 'SUPER EDs'. Next, a method for integrating the 2001 OAs with the SUPER EDs by using postcodes is discussed. However, the postcode-based approach is shown to be inadequate, so the 2001 OAs are merged with the SUPER EDs using residential buildings, obtained from ADDRESS-POINT™. The creation of CATTs means that, For the first time in Scotland, the reliable analysis of changing demographic, social, and economic circumstances can be explored at the local level.

4.2. Existing methods of creating 'consistent' geographies

Although the GROS attempted to keep these differences to a minimum, changes made to boundaries were inevitable to reflect changes in the population size. Thus, in order to conform to confidentiality thresholds, areas where the population declined the size of the zones were increased. Conversely, areas in which the population had grown over time were split into two or more smaller zones. These subtle changes make the temporal comparison of small area census statistics difficult.

Until recently, however, it was possible to compare census data at the administrative District level because there were very few alterations to these boundaries since 1971. There were only 56 administrative Districts in Scotland until the mid 1990s, with 1991 populations that ranged from 10,623 in Nairn to 662,853 in Glasgow City. The administrative District was a useful medium for reporting mortality and demographic data because the numerator and denominator values were large enough to make statements about the relationship between mortality and social characteristics with statistical validation. In addition, the District names are more likely to be recognised by lay people interested in such analyses.

However, because each District was so large, and the populations were so different, that the results that were reported represented the level of health that was experienced by the 'average' population within that District. It is very likely that villages nested within a District, the Highlands, Grampian, and Dumfries and Galloway, may have a considerably better or worse health than is reported for the District. Exeter *et al,* (2002) found that such pockets (areas) of deprivation existed in Output Areas nested within Pseudo Postcode Sectors in Scotland, and as there is an association between deprivation and mortality (e.g. Dorling 1997), it could be assumed that mortality would be no different. If pockets of significantly different mortality rates do exist within Districts, then a more local geography should be used in an attempt to identify these areas, and a more beneficial local geography would be one that facilitates comparisons through time.

Various approaches exist for creating consistent geographies that could be used to facilitate spatio-temporal analyses of two or more different censuses. The first consideration when creating a consistent geography is to decide upon a 'base' geography, onto which different geographical zones will be transformed. Norman *et al,* 2003 defined four different approaches to setting a base geography. These included freezing geographical history, updating historic data to contemporary zones, creating designer zones, or the aggregation of individual data to the geography that is best suited to the research question.

Freezing geographies requires the use of a base geography, typically the geography of the earliest time period under observation, but also requires a detailed account of changes made to boundaries over the entire period such that data collected from later periods can be accurately allocated back to the frozen geography. One disadvantage of freezing geographies is that underlying spatial processes such as internal migration and changes in population structure are ignored. Thus, frozen geographies may not necessarily be an accurate representation of areas in the later time periods.

Similarly, updating data from earlier time periods to a current geography requires information about the changes made to boundaries through time. However, if mortality trends were being analysed in order to identify areas that were most in need of policy interventions, it could be argued that the contemporary boundaries would be more appropriate as they reflect the current social structure of the population under observation (Norman *et al.* 2003).

The most freedom of choice, with regard to creating a base geography, results from data being recorded at the individual or household level. In this case, data can be attributed to a target zone using a point-in-polygon procedure within a geographical information system (GIS). This approach has been used to allocate address-based resources to small areas (meshblocks) in two cities within New Zealand for the creation of a community resource accessibility index (Witten *et al.* 2003). The aggregation of individual or household data is less common in the United Kingdom. However, this is expected to change with the development of the Ordnance Survey's (OS) ADDRESS-POINT™ data, a dataset that defines and locates all residential, business, and public postal addresses in Great Britain (Ordnance Survey 2004). Each record in the ADDRESS-POINT dataset contains a gird reference, as well as other information that can be used to aggregate to an appropriate level of analysis. In Sweden, authorities maintain very detailed information at the individual level, and generate annual demographic reports for counties and municipalities (Statistics Sweden 2003).

Once the base geography is decided upon, there are a number of approaches that can be used to create a consistent geography. When individual data are not available, the most common approach is to create Geographic Conversion Tables, or GCTs (Simpson 2002). GCTs exist in many forms, and under aliases such as 'gazetteers' or 'lookup tables', but most consist of three fields of data specifying a 'source', a 'target' and a 'weight'. The weight ranges from 0 to 1, and represents the proportion of the source geography that lies within the target geography.

This type of approach is known as areal interpolation (Flowerdew and Green 1994; Goodchild *et al.* 1993). The simplest form, areal weighting, assumes that the variable of interest (e.g. population) is uniformly distributed within the source zone. If the proportion of source zone *s* that is in the target zone *t* is known, it is simple to calculate the estimated value for the area of intersection, and then to total the values to achieve a target zone estimate. The problem with this method is that variables are usually not distributed evenly over geographic space, and consequently the error may be substantial. If part of the source area is known to be uninhabitable (perhaps because it is under water), dasymetric-mapping techniques can be used to adjust the estimates. Flowerdew and Green (1994) developed techniques for 'intelligent' areal interpolation, which can take into account any additional data relating to the source zones and may provide further clues about the distribution of the variable of interest within the source zones.

Data that are converted using the GCT concept are potentially subject to errors resulting from the construction of the conversion table, and/or from the data conversion itself. Simpson (2002) identified two types of error related to the construction of GCTs, *best-fit whole allocation of source units rather than weighted allocation* and *incorrect calculation of the weights*. The former refers to cases in which the source data are wholly allocated to a single target unit that it best fits, based on some criterion. The latter refers to the incorrect allocation of the source geography to the target geography, which will in turn affect the weights assigned to the GCT and hence the population estimates that are created for the target geography.

Goodchild *et al,* (1993) provided an example of areal interpolation in which socio-economic data for 58 counties in Southern California were associated with data from 12 hydrological study areas. In their analysis, the counties were treated as the source geography and the hydrologic areas were the 'target' zones. They used two different interpolation techniques to associate published data at the county level to the published data for the hydrologic study areas. Their first approach consisted of direct areal weighting from counties to basins, using the 'uniform source-zone density' assumption. This approach assumed that because the number of source zones (counties) was at least as large as their target (hydrologic study areas), the population densities for the target zones could be estimated using the source zone populations, and that the areas of overlap of a source zone with each target zone. The uniform source-zone approach assumes that the population distribution in the source and target zones is uniform, which is not normally the case.

The second approach used a set of 'control zones', in which a third set of zones was used, and assumed to have constant densities. In an intermediate step, the areas of overlap between the source zone and control zone, and the areas of overlap between target zone and the control zone are estimated, prior to the areal interpolation process. Goodchild *et al*, (1993) used a file containing four control zones that were subjectively created to divide Southern California into broadly similar areas. They found that for all cases in which the control zone densities were used, the mean percentage error and mean absolute percentage error were considerably smaller than for the source-zone approach.

Another approach is to 'remove' the boundaries and use the grid references or centroids of each areal unit to construct a smoothed population surface. The original method of this type is Tobler's pycnophlyactic interpolation (Tobler 1979), but there are a number of weighting methods that can be applied when estimating the population using these methods, including inverse-distance, kernel estimation and kriging. Each technique results in very different population estimates for the cells across the study region.

In the UK during the 1980s, it was thought that various government agencies would make spatio-temporal comparisons and publish conflicting reports if a suitable base geography was not established. Therefore, the Department of the Environment funded the Office of Population and Census Statistics (OPCS; now ONS) to construct a boundary file, known as Census Tracts for which results from comparable data could be analysed and presented. Approximately 48,300 Census Tracts were created for former County Boroughs or urban Districts in England and Wales. Each Census Tract comprised of one or more EDs from 1971 and 1981 that nested within unchanged boundaries. These 48,300 Census Tracts made comparisons between the 81,000 EDs from 1971 and 82,500 EDs from 1981, and accommodate 76% of the 1981 population (Morgan and Denham 1982).

In rural areas, the OPCS used Civil Parishes as their consistent geography. The Civil Parishes were combined 28,350 EDs from 1971 and 29,800 1981 EDs. However, there were approximately 100 Civil Parishes that contained over 10,000 residents in 1981, and so these were then divided into Census Tracts of similar size in population to those in urban areas Whilst Morgan and Denham (1982) saw the potential of using the Tracts and Parishes as a convenient geography to which future Small Area Statistics (SAS) datasets could be linked, the OPCS did not publish lookup tables to link the 1991 census data to the Tracts.

Bracken and Martin (1995) used surface modelling techniques to link 1981 and 1991 ED data for England and Wales. The 1991 ED data were left unchanged, but the 1981 ED data were remodelled to the 1991 geography. Although the boundaries for some EDs did not change between 1981 and 1991, the boundaries for many others did change. In these cases the 1981 ED centroids were allocated to a 1991 centroid that was within 100 metres of the 1981 ED centroid. If no match was possible, the 1981 data were reapportioned to the nearest 1991 EDs, and a distance function was used so that the population and variable totals were preserved. This approach provides a 'best fit' solution to matching the 1981 and 1991 geographies, but inevitably there will be error involved in the process, the scale of which will vary geographically.

More recently, the Economic and Social Research Council funded the creation of a system that provides an online service that links Ward-level data from 1971, 1981 and 1991 (Dorling *et al.* 2001). The Linking Census through Time (LCT) project used the 1981 Wards as the base geography from which analyses of Ward-level data from 1971, 1981, and 1991 can be derived. Martin *et al.* (2002) discussed four major barriers faced when developing the LCT project relating to the boundary configurations, the questions asked at each census, the social and political environment in which each census was conducted, and the difficulties users face when trying to access census results.

To solve the problems associated with boundary changes, the 1971 and 1991 ED data were aggregated to 1981 Wards using typical point-in-polygon techniques. In addition, the point-in-polygon technique was used to create over 30 datasets ranging in scale from 1981 Wards, to totals for the whole of Britain, and ranging in time from the 1898 Registration Districts through to the 2001-based Government Office Regions (Martin *et al.* 2002).

The number of SAS tables increased dramatically between 1971 and 1991, and the contributors to the LCT project selected about 100 key variables that were believed to be comparable with the 2001 census. Each key variable fell into one of ten broad census topics: demography; migration, country of birth and ethnicity; economic activity; tenure; living arrangements; household composition; communal establishments; industry; occupation; travel and transport; and qualifications (Martin *et al.* 2002). Another problem associated with the census questions and variables was the 1991 census undercount, whereby there was an enumeration deficit of over 1.3 million people across Britain. The census undercount was rectified for the base populations as part of the Estimating with Confidence project Simpson *et al.* 1996), and each 1991 SAS table was updated for the LCT project (Martin *et al.* 2002). Finally, online access to data created as part of the LCT overcame many of the problems associated with disseminating census data. Moreover, the website (http://census.ac.uk/cdu/software/lct/) provides functionality for novice and for advanced census data users.

An alternative approach to the techniques outlined above would be to adopt a 'merging' strategy. This strategy would use two source geographies, one of which would also be designated as the target geography. However, the fundamental difference between the merging strategy and existing approaches would be that whenever a zone in the source geography overlaps more than one zone in the target geography, the affected areas in the target geography are merged. Furthermore, since the affected target zones are merged, the zones from the source geography fit neatly within the output target zones, thus removing any need for population estimation techniques. This merging strategy was adopted for the creation of the CATTs and will be discussed further in the next Sections.

4.3. Constructing SUPER EDs

For the construction of CATTs, the 1981 ED boundaries were used as the base geography, since they were generally larger than the 1991 or 2001 OAs. The 1981 ED boundaries were not digitised, but it was possible to create *pseudo EDs* using the 1991 OAs. In 1981 there were 17,767 EDs in Scotland, which were generally represented using population-weighted centroids, and/or Thiessen polygons. In

1991 there were 38,098 'unrestricted' OAs for which the boundaries were digitised. However, by removing the alphabetical suffix from the 1991 OAs, a 'pseudo ED' could be developed. Using the *dissolve* function in ArcInfo the 1991 OA boundaries were aggregated based on the pseudo ED labels, and produced 16,096 individual pseudo ED zones (Figure 4-1a). Hence, there were 1,671 1981 EDs that could not be created from the 1991 OAs. This was because the postcodes of some 1981 EDs had too few persons and/or households in 1991 to become distinct 1991 OAs, so were absorbed by neighbouring zones.

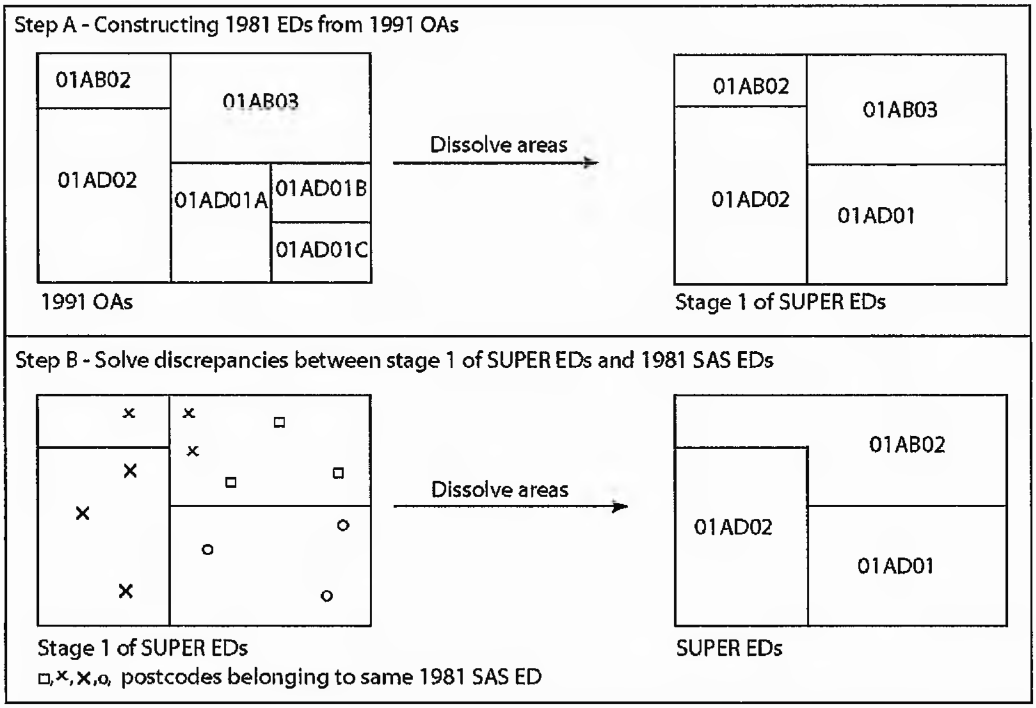

Figure 4-1 A summary of steps used to create the 'Super EDs'.

A lookup table was created by the GROS that recorded the instances where postcodes were allocated to a different 1991 OA than would be expected based on the zone labelling conventions used, with the reasons why the anomaly arose, as shown in Table 4-2. Because of the zone labelling convention used for the 1981 EDs and 1991 OAs, it was possible to create a pseudo ED code for each record in the lookup table (see Table 4-2, column 5), thus identifying the allocation of 1981 EDs that were 'absorbed' during the creation of the 1991 OAs. The first row of Table 4-2 should be interpreted as: "Postcode DG12 5PXB, which was introduced in August 1973, was part of the 1981 ED '09AN01', but because it contained too few households in 1991 to meet the threshold, it was amalgamated with the neighbouring 1991 OA '09AD21'. In addition, the 1981 ED '09AN01' was associated with the pseudo ED '09AD21'.

The lookup table from the GROS consisted of 2,084 unique records, which associated 1,874 1981EDs with 1,530 pseudo EDs. As Table 4-2 shows, there was a wide range of reasons for the unusual allocation of postcodes, although postcodes that contained too few households to become distinct 1991 OAs was the most common. These reasons have been summarised in Table 4-3. Aside from the postcodes having too few households, the plurality of anomalies arose from postcodes being allocated to unusual 1991 OAs; the Special EDs from 1981 been either allocated to ordinary (unrestricted) 1991 OAs, or to special ED/OAs in 1991; or resulted from the relabelling of Postcode Sectors in the Grampian administrative District between 1981 and 1991. There was only one typographical error identified by the GROS, in which one 1981 ED was labelled 20BR30 when the correct label was 29BR30.

1981 ED	*Postcodes*	*History*	*1991 OA*	*Pseudo ED*
09AN01	DG125PXB	Int 08/73. Live. At NY 1044 6604.	09AD21	09AD21
	DG125PY	Int 08/73. Live. At NY 1064 6714.	09AD21	
	DG125PZA	Int 08/73. Live. At NY 1134 6744.	09AD21	
	DG125RT	Int 08/73. Live. At NY 1184 6884.	09AD21	
		Too few households to form a separate OA in 1991.		
10AH08	DG7 2BG	Int 08/73. Live. At NX 6064 6064.	10AH06	10AH06
	DG7 2BH	Int 08/73. Live. At NX 5984 5874.	10AH06	
	DG7 2BPB	Int 08/73. Live. At NX 5594 6224.	10AH06	
	DG7 2BW	Int 08/73. Live. At NX 5754 6074.	10AH06	
		Too few persons to form a separate OA in 1991.		
07AH03	FK7 0AE	Int 08/73. Live. At NS 8086 9056.	07AH03	07AH03
	FK7 0AS	Int 12/82. Live. At NS 8110 9018.	07AF09A	07AF09
	FK7 0AR	Int 08/73. Del 07/80. At NS 8074 9045. In AP.	07AH03	
		Postcode in an unusual OA in 1991.		
41DH26	G42 7JG	Containing postcode. Int 08/73. Live.	41DH22B	41DH22
		Special ED in 1981. In ordinary OA in 1991. OA of postcode given.		
41FE01	G78 2NX	Int 08/73. Live	49AF12C	49AF12
		A local government boundary change between Censuses transferred the only postcode in this ED from Glasgow to Renfrew District.		
41FF01	G81 1EWB	Int 08/73. Live. At NS 5108 6935.	41BH02B	41BH02
		Too few households to form a separate OA in 1991.		

Table 4-2 An excerpt from the GROS spreadsheet tracking postcode level changes between 1981 and 1991

Anomaly Code	*Description*	*Count*
1	Too few households	1,161
2	Too few persons	94
3	One or more postcodes in unusual OA in 1991	262
4	Special ED in 1981, Ordinary OA in 1991	224
5	Special ED in 1981, Special ED/OA in 1991	120
6	Boundary Changes	119
7	Shipping ED in 1981, one or more OAs in 1991	37
8	Grampian Sectors relabelled	250
9	Postcodes deleted between 1981 and 1991	29
10	Postcodes introduced between 1981 and 1991	18
11	Ordinary ED in 1981, Special ED/OA in 1991	4
12	Typographical Errors	1
13	Hospitals/ prisons change name between 1981 and 1991, but still in same location	4

Table 4-3: A Classification of anomalies described in the lookup table of anomalies provided by the GROS

For the creation of a consistent 1981 to 1991 census geography, discrepancies between the allocation of postcodes to 1981 EDs and 1991 OAs needed to be accounted for. A Microsoft Access® database was created, which contained the 17,767 1981 ED codes and the 16,096 pseudo 1981 ED codes in separate tables. A new table was created, which contained the 15,975 instances where the same ED code existed in both tables (called the BASE TABLE). There were 121 pseudo ED codes missing from this table which was due to the zone relabelling that took place in the Grampian region. Furthermore, there were 1,792 1981 EDs that were not accounted for in the BASE TABLE. Appending the appropriate data (i.e. columns 1 and 5 in Table 4-2) from the lookup table provided by GROS to the BASE TABLE solved these shortcomings.

The BASE TABLE now contained 18,204 records of which 18,024 were unique and related 16,110 pseudo EDs to 17,765 1981 EDs. There were two 1981 EDs missing from the table: 31AF25 and 31AJ34, neither of which were included in the GROS lookup table but were allocated to a pseudo ED using a point in polygon query. Consequently, the 1981 ED '31AF24' was allocated to the pseudo ED '31AE15' while the 1981 ED '31AJ34' was assigned to the pseudo ED '31AJ33'. The incorrectly referenced 1981 ED (anomaly 12, Table 4-3) was changed from '20BR30' to '29BR30'. Furthermore, all of the references to the 'shipping' EDs in the BASE TABLE were removed, because it was thought that these EDs would not be influential in future analyses. At this stage, these extra EDs were untouched, under the assumption that they would be merged with other pseudo EDs in the next stage. Despite there only being 16,096 zones in the pseudo ED file, there were an additional 14 zones referred to in the BASE TABLE, one of which was associated with a shipping ED and removed. The remaining 13 'extra' pseudo ED codes arose because the lookup table referred to some special 1991 OAs, which did not have any geographical boundaries. These changes increased the number of unique records to 17,907 and associated 16,109 pseudo EDs to 17,767 1981 EDs.

From the number of records in the BASE TABLE, it was evident that some 1981 EDs overlapped more than one pseudo ED, and these instances needed to be identified and rectified. Since no zones existed for the 1981 EDs, it was not possible to use areal interpolation methods to apportion the demographic data to the necessary pseudo EDs. Thus, the merging strategy was devised.

The basic rule in the merging strategy was that whenever a 1981 ED was referenced to more than one pseudo ED, the affected pseudo EDs were merged. The merging of the pseudo EDs would result in a new boundary file, called SUPER EDs. To create these SUPER EDs, the 17,907 records in the BASE TABLE were exported from Access as a text file and run through a Fortran program to create a cross-tabulation linking all occurrences of the 1981 ED codes to the same pseudo ED code. This resulted in a matrix containing 16,109 rows (i.e. one for each pseudo ED), and a varying number of columns listing the 1981 EDs that were associated with a pseudo ED, depending on the number of times a pseudo ED was associated with a 1981 ED. In most cases, there were one or two columns for each pseudo ED, but one pseudo ED in Glasgow was associated with 22 different 1981 EDs.

Next, the program sought instances in the matrix where there was more than one reference to either a 1981 ED or a pseudo ED, and merged the rows in the matrix (and hence the pseudo EDs) accordingly (Figure 4-1b). For example, there were two references of the 1981 ED '41CG18', which was associated with the pseudo EDs '41CG18' and '41CL06', and therefore these two pseudo EDs were merged. When pseudo EDs were merged, the SUPER ED that was created was labelled alphabetically, which meant that in this example, the SUPER ED was labelled '41CG18'.

Following the merging process, there were 15,921 SUPER EDs, and two additional files were output from the program, one linking the SUPER ED labels back to the 1981 EDs, and another linking the SUPER EDs back to the pseudo EDs. An additional field, which served as a zone identifier, was exported in each file and could be used to dissolve the pseudo EDs to create the SUPER EDs. The former file could be used as a lookup table to aggregate the official 1981 ED data downloaded from sources such as CASWEB (http://www.casweb.ac.uk) or the Small Area Statistics PACkage (SASPAC) to the SUPER EDs, while the latter file was used to merge the necessary pseudo EDs to create the SUPER EDs.

Manual checking of the SUPER EDs highlighted a small number of occasions where two non- contiguous 1981 EDs were combined into a single 'SUPER ED'. In these instances all of the 1981 EDs that fell between non-adjacent 'SUPER EDs' were merged. In addition, a small number of errors were found in the GROS lookup table, which resulted in non-contiguous zones that were very distant from each other. These generally arose from typographic errors, and were rectified using the postcode information in the Central Postcode Directory (CPD). In addition, there were 210 islands and lochs that were included in the original 1991 OA boundary file that did not have any populations. These islands and lochs were labelled with the first six characters of their name and included in the SUPER EDs file.

In 1981, each ED was required to have a minimum population of 25 people otherwise the data were suppressed at the ED level, and/or merged with adjacent EDs. However, this rule did not apply to the total population count tables in SASPAC, and as a result there were some SUPER EDs that reported populations between 0 and 25. Zones with such small populations would be problematic if mortality analyses were carried out on them. Furthermore, since the minimum populations for 1991 and 2001 OAs was 50, it was thought best to maintain consistency, and so all SUPER EDs with a population less than 50 were manually merged with their adjacent zone with the lowest population. These manual modifications decreased the number of SUPER EDs from 15,921 to 15,739 unique zones. These 15,739 zones allowed reliable comparisons to be made between 1981 and 1991 census data, and are shown in Figure 4-2. Geographic conversion tables (GCTs) were created that linked each 1991 OA to a SUPER ED. Similarly, GCTs were created linking the 1981 EDs from the SAS, and the pseudo EDs for 1981 derived from the 1991 OAs, to the appropriate SUPER ED. Unlike conventional GCTs, these lookup tables only contained 'source' and 'target' fields, as none of the 1981 EDs and 1991 OAs were located in more than one SUPER ED.

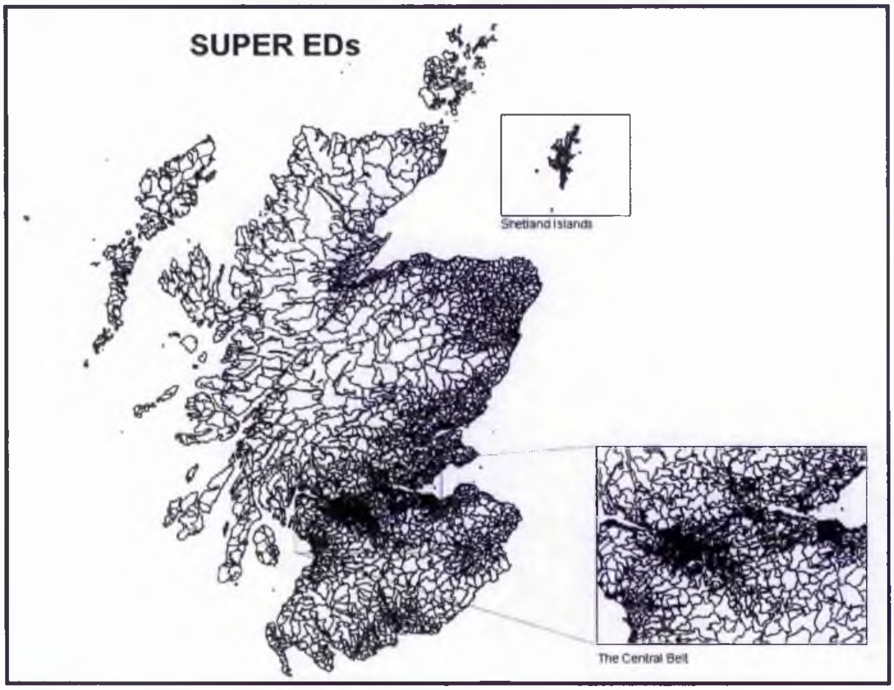

Figure 4-2 SUPER EDs - a consistent link between 1981 EDs and 1991 OAs

It should be noted that there were 15,739 unique SUPER ED zones not including the 210 lochs and islands scattered throughout Scotland. Furthermore, 288 of the SUPER EDs comprised of more than one polygon. These 'multiple-extent' SUPER EDs arose for three main reasons. First, a SUPER ED might consist of a group of islands with relatively low populations. This was particularly common in the Western Isles, Orkney and Shetland. Second, a SUPER ED might be have been split by natural features, such as lochs and estuaries. Third, the individual polygons of a multiple-extent SUPER ED might be 'anchored' together. One example of an anchored SUPER ED would be where the top-right corner of one polygon and the bottom-left corner of another polygon (with the same code) touch. Anchored SUPER EDs could be created when the postcode of one 1981 ED was reallocated to an adjacent 1991 OA.

4.3.1. Descriptive Statistics for SUPER EDs

Table 4-4 presents the summary statistics of the 1981 and 1991 total populations aggregated to EDs/OAs and SUPER EDs. One might be surprised to see that the minimum population for 1981 EDs was indeed zero (0), even though there was a population threshold of 25 persons enforced. However, the number of males, number of females, total population and total number of households are the only counts that were not suppressed if they fell below the minimum thresholds. All other variables that did not meet the confidentiality thresholds were suppressed at the ED level, and added to the nearest ED that was located within the same unit of the next possible level of aggregation (Dewdney 1983).

The 56 shipping EDs from 1981 and one shipping OA from 1991 have been excluded from all analyses, because shipping zones have been abolished in 2001, and also because they did not have any geographical meaning. Furthermore, since there were only 1,350 people (0.02% of the total population) recorded across the 1981 shipping EDs, it is not likely that their exclusion will hinder the results observed in later chapters.

The total population reported for 1991 in Table 4-4 is commonly known as the 'uncorrected' 1991 population, and was extracted from CASWEB. It has been estimated that approximately one million people were excluded from the 1991 Census (Mitchell *et al.* 2002), and the ONS suggested that this would not be problematic. However, the academic community disagreed, and the Estimating With Confidence (EWC) project (Simpson *et al.* 1996) was established in order to provide a more accurate population base. The EWC project estimated the 1991 Scottish population as 5,107,000, compared with the total population of 4,9998,320 according to CASWEB. However, the EWC project did not re-estimate the populations for the 156 special OAs from 1991, rather they were omitted from their analysis. The EWC project adjusted a range of variables from the 1991 census, but the lowest aggregation for which these data were made available from the LCT website (Dorling *et al.* 2001) was the Ward. Therefore, in this study the 1991 uncorrected data are used.

	N	*Total*	*Minimum*	*Maximum*	*Mean*	*Std Deviation*
1981 EDs	17,711	5,033,965	0	1,333	284.23	145.42
1991 OAs	38,253	4,998,320	50	773	130.66	46.54
SUPER EDs (1981 Census)	15,739	5,033,965	50	1,968	319.84	133.23
SUPER EDs (1991 Census)	15,739	4,998,320	50	5,131	317.58	164.74

Table 4-4 Descriptive statistics of the 1981 ED and 1991 OA total population, and aggregated to SUPER EDs

4.4. Constructing CATTs Using Postcodes

The final step was to account for the 2001 Census geography. In 2001, there were 42,604 Output Areas, and an additional 73 zones that were labelled 'N.T.' (Not Tagged), which were lochs or islands that did not have any populations. For 1991, when the GROS digitised the postcode geography, they also included the 'major' uninhabited islands, but excluded clusters of rocks. Since then the GROS has relied upon the Postcode Address File (PAF), which is maintained by Royal Mail to distinguish between populated and unpopulated islands. As a result, there were only 73 lochs and islands included in the 2001 OA boundary file. Each 'N.T.' zone was assigned the zone label of the corresponding loch in the SUPER ED file. This resulted in 42,677 unique polygons in the 2001 boundary file. There were 56 OAs in 2001 that comprised more than one polygon, and consequently there were 42,747 polygons in the 2001 boundary file.

The GROS attempted to maintain consistency between the 1991 and 2001 census geography, although Table 4-1 showed that the maintenance of Council Areas and Locality boundaries was thought to be more important than retaining consistency between OAs. The dramatic increase of approximately 30,000 postcodes in the 1990s, and increased confidentiality thresholds, meant that some inconsistencies were inevitable at the OA level. Some 2001 OAs were created by sub-dividing 1991 OAs, but because the naming conventions used to label OAs changed between 1991 and 2001 it was more difficult to identify these occurrences.

To date, the GROS has not published a table outlining the differences between the allocation of postcodes to 1991 and 2001 OAs, similar to the table used in the construction of SUPER EDs. However, a Postcode to Output Area (PCOA) lookup table was released by the GROS as part of the 2001 Census data dissemination. The PCOA reports the allocation of 139,045 'small user' postcodes to 42,604 2001 OAs. Additional information, such as the current number of households, the number of delivery points, the date of introduction and deletion (if appropriate) and a grid reference for each postcode was obtained from the Central Postcode Directory (CPD) and provided by the GROS. Although the majority of small user postcodes comprised of residential addresses, there were a small proportion of small user postcodes consisting of commercial addresses, or a mixture of residential and commercial addresses. Therefore the 'commercial' postcodes were removed from the analysis.

The PCOA and CPD were merged, and the 2001 OA code and grid references of the 132,536 postcodes containing at least one household were imported to an ArcGIS point file called Validpcodes. The *intersection* command in ArcInfo was used to undertake a point in polygon query, in which each postcode was assigned to a SUPER ED. After the intersection process, the 132,536 postcodes were allocated to the 42,604 OAs from 2001, but the postcodes were only allocated to 15,692 SUPER EDs. Thus, there were 47 SUPER EDs that did not contain any 2001 postcodes. These were located in Dundee, Edinburgh, Glasgow and Renfrewshire, and resulted from the demolition of poor quality housing estates, which occurred in these cities during the 1990s. To ensure consistency through time, these SUPER EDs were manually allocated to one or more 2001 OAs. The manual corrections allocated 47 SUPER EDs to 58 OAs. A list of the 2001 OAs and their corresponding SUPER EDs was extracted from the results of the intersection process, and appended to the file of manual corrections. This resulted in a text file (super2pccatt.csv) containing 45,551 unique records, linking 15,739 SUPER EDs to 42,604 OAs from 2001.

The super2pccatt.csv file was run through a Fortran cross-tabulation program, using the SUPER EDs as the 'key' attribute. First, the cross-tabulation program generated a matrix that linked each SUPER ED to one or more 2001 OAs. Next, the program sought instances where the 2001 OAs were associated with more than one SUPER ED, and merged the necessary SUPER EDs together. This merging process produced 12,988 unique POSTCODE CATTs.

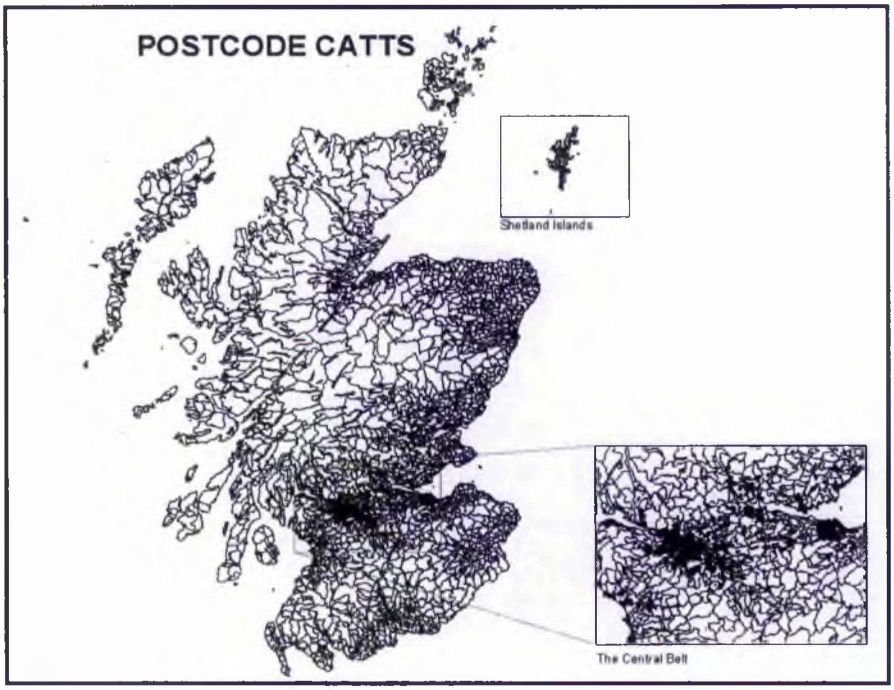

Figure 4-3 Postcode CATTs

Once again, the number of lochs and water bodies across Scotland created duplicate polygons. There were 214 POSTCODE CATTS that had more than one polygon, and while the majority of these resulted from the SUPER EDs spanning lochs, or 'anchor' polygons, there were some non-contiguous zones. An example of how the non-contiguous CATTs came about is provided in Figure 4-4. In this figure, the 2001 OA boundary is oddly shaped, but because the population is not evenly distributed across the zone, the postcodes are clustered in two corners of the OA (Figure 4-4a). During the point in polygon process, the postcodes of this OA were correctly allocated to three SUPER EDs, two of which are non-contiguous (Figure 4-4b). This in turn produced a non-contiguous POSTCODE CATT (Figure 4-4c).

This CATT was manually corrected to restore contiguity, and the merging process was repeated, and produced one contiguous POSTCODE CATT, as shown in Figure 4-4d. After solving all of the non-contiguous zones, there were 12,970 POSTCODE CATTs, which are shown in Figure 4-3.

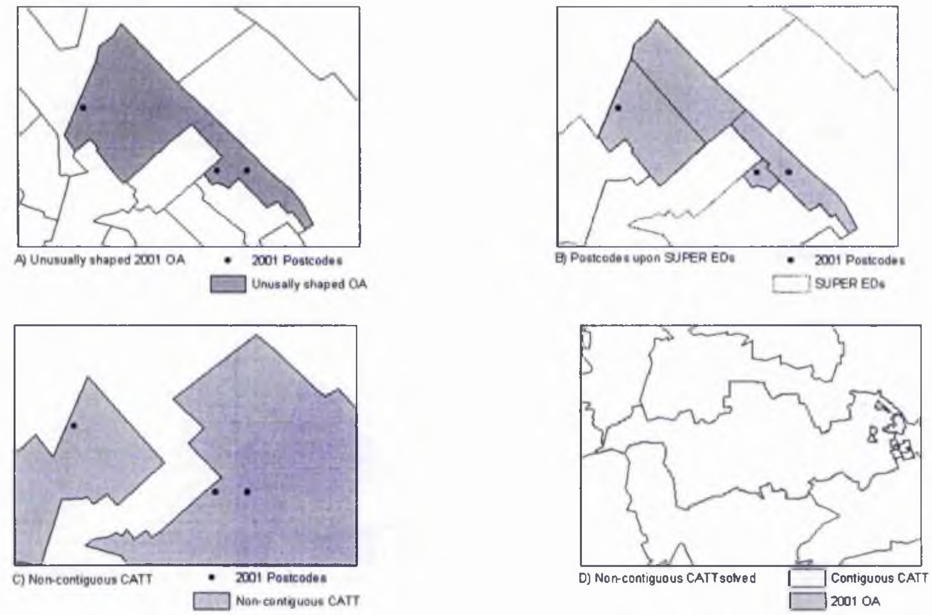

Figure 4-4 An example of an unusually shaped 2001 OA, the distribution of the postcodes and the SUPER ED boundaries

4.4.1. Descriptive Statistics for CATTs based on Postcodes

The summary statistics for the 1981, 1991 and 2001 total population aggregated to POSTCODE CATTS are given in Table 4-5. The mean population for each census year was relatively stable and was approximately three times greater than the average 2001 OA population. The standard deviations increased dramatically through time, suggesting that although the average size of the POSTCODE CATTs remained relatively stable, the population distribution was much more dispersed for 1991 and 2001 than 1981. The minimum population for the POSTCODE CATTs was expected to be 50 for all time periods, as this was the threshold enforced for the construction of the SUPER EDs, and also for the 1991 and 2001 OAs. In 1981, the POSTCODE CATT with the highest population was located in Dundee (zone

52AH01), but in 1991 and 2001, the POSTCODE CATT with the highest population was a large zone on the outskirts of Edinburgh (29BS05). Interestingly, while zone 29BS05 has experienced growth from 9,671 in 1981 to 13,540 in 2001, the POSTCODE CATT 52AH01 experienced a population decline from 9,818 in 1981 to 5,679 in 2001. One POSTCODE CATT in 1981 (32AD19) and 2001 (45AF01) had the minimum population of 50, and in 1991, there were four POSTCODE CATTs (06AS20, 16AU10, 30AK18 and 40AG04), which had the minimum population of 51.

Table 4-5 also suggests that contrary to recent publicity in official documents (e.g. GROS 2002) the total population has increased slightly since 1981. The official demographic reports for Scotland are based on mid-year population estimates, and not from the census. Furthermore, the mid-year estimates are likely to better reflect the demographic change, especially for the period 1991-2001, given the problems associated with the 1991 census undercount discussed previously in this chapter.

	Minimum	*Maximum*	*Total*	*Mean*	*Standard Deviation*
1981	50	9,818	5,033,965	388.12	353.49
1991	51	10,742	4,998,320	385.38	378.62
2001	50	13,540	5,062,011	390.28	454.15

Table 4-5 Descriptive Statistics for the total population from 1981, 1991 and 2001, aggregated to POSTCODE CATTs (note: N = 12,970)

Statistically, the POSTCODE CATTs look impressive, with the mean populations remaining relatively constant through time. Furthermore, the total number of POSTCODE CATTS is approximately 80 percent of the total number of pseudo EDs that were created from the 1991 OAs, which suggests that overall, there have been very few changes to the small area census geography of Scotland. However, a visual comparison of the POSTCODE CATTS highlighted that the POSTCODE CATTS did not accurately represent the geography of the 2001 OAs, and is demonstrated in Figure 4-5. The 2001 OA (shaded) comprised of four postcodes, represented by the solid dots. Using the intersect process, this particular 2001 OA was allocated to the POSTCODE CATT number 1, as all of the postcodes belonging to this 2001 OA fell in the same SUPER ED. However, if the 2001 OA boundary is traced more carefully, it becomes apparent that it overlaps three

SUPER EDs. Under the rules associated with the merging strategy, the three SUPER EDs that the 2001 OA overlaps should have been merged to create one POSTCODE CATT in order to accommodate the OA. Furthermore, it should also be noted that because postcode centroids were summary points for a variable number of households, some error would have been introduced during the point in polygon query. In addition, this postcode-based error was not introduced during the creation of the SUPER EDs, as the postcode histories were used to ensure consistency through time. Thus, the use of postcodes grid references as a means to integrate the 2001 OA geography with the SUPER EDs proved to be inadequate, and an alternative approach was required.

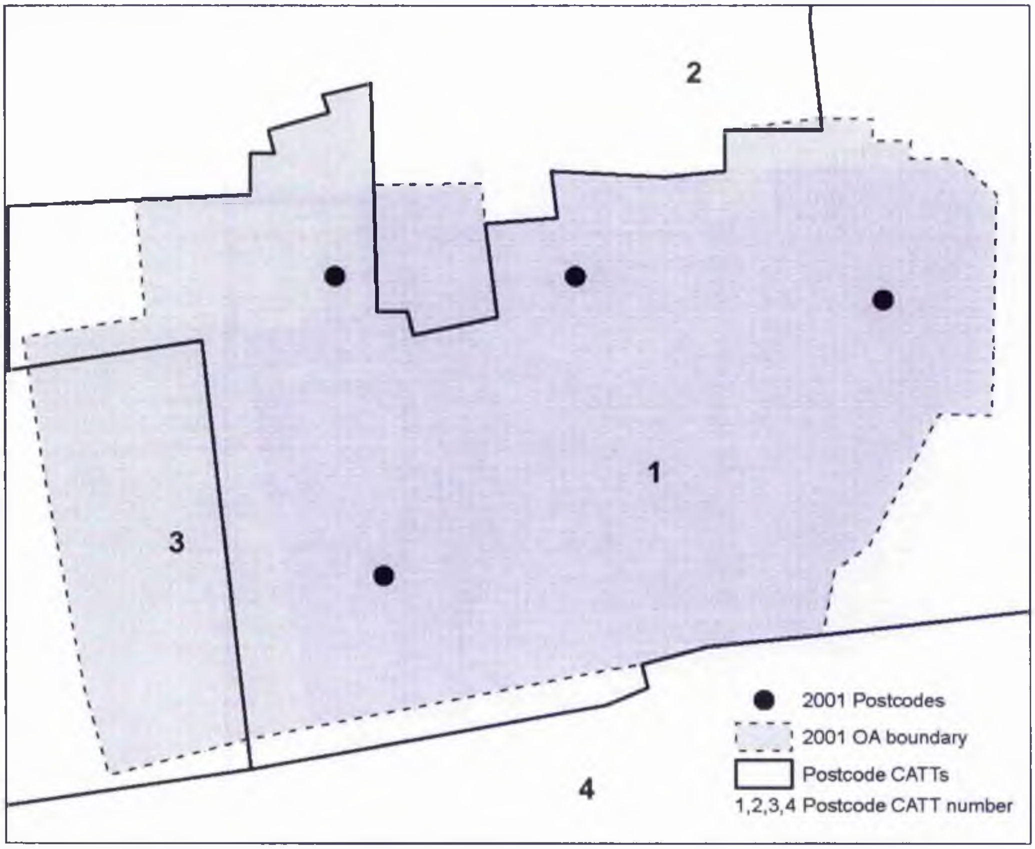

Figure 4-5 A visual examination of the Postcode CATTS, highlighting the misrepresentation of the 2001 OA geography.

4.5. Constructing CATTs using ADDRESS-POINT™

4.5.1. Constructing CATT0s

Since the postcode grid references did not produce satisfactory results, an alternative strategy was needed, in which the polygons of the 2001 OAs and SUPER EDs were overlapped and merged. For this approach, ArcInfo coverages were used. The topological structure of ArcInfo coverages does not permit multi-part polygons. Rather, each individual polygon becomes a separate entity, but retains the zone label. Thus, there were 42,747 OA polygons in 2001, of which there were 42,604 unique labels, and there were 16,260 SUPER ED polygons, of which 210 were lochs and islands, and 15,739 zone labels were unique.

Figure 4-6 provides a summary of the steps used to create the Intersection-based CATTs. First, the 42,747 OAs from 2001 were overlain upon the 16,260 SUPER EDs and merged together using the Intersect command in ArcInfo (Figure 4-6i-iii). This produced a new file (MPINTCOV) that contained 112,413 polygons. This large number of polygons demonstrates that there were some substantial differences between the SUPER ED boundaries and the 2001 OA boundaries. The question was whether these were significant differences involving the deliberate redrawing of boundaries so that some households were moved between areas, or whether they were mainly sliver polygons created by merging two datasets that had been digitised separately Thus, were areas B1 and B5 in Figure 4-6iii slivers, or intentional boundary changes designed to reallocate people between different areas, perhaps because of confidentiality requirements? If these areas were indeed slivers they could be deleted. However, if they were intentional changes between 1991 and 2001, it was pertinent that they were retained.

It was apparent that the postcode grid references could not be used to answer these questions, and also that manual identification of true sliver polygons would not be practicable. However, ADDRESS-POINT™ (e.g. Figure 4-6iv) could be used to identify those polygons which did not contain any residential buildings in 2001. Unfortunately, ADDRESS-POINT™ is not available to the academic community, so help was sought from the GROS, who overlaid the 2,278,170 residential addresses from ADDRESS-POINT™ upon the 112,415 MPINTCOV polygons and reported the number of points that fell within each polygon. There were 54,776 polygons that did not contain any ADDRESS-POINT™ data, while the remaining 57,639 polygons contained between one and 1,739 points. The mean number of ADDRESS-POINTs was 41.26, with a standard deviation of 29.18.

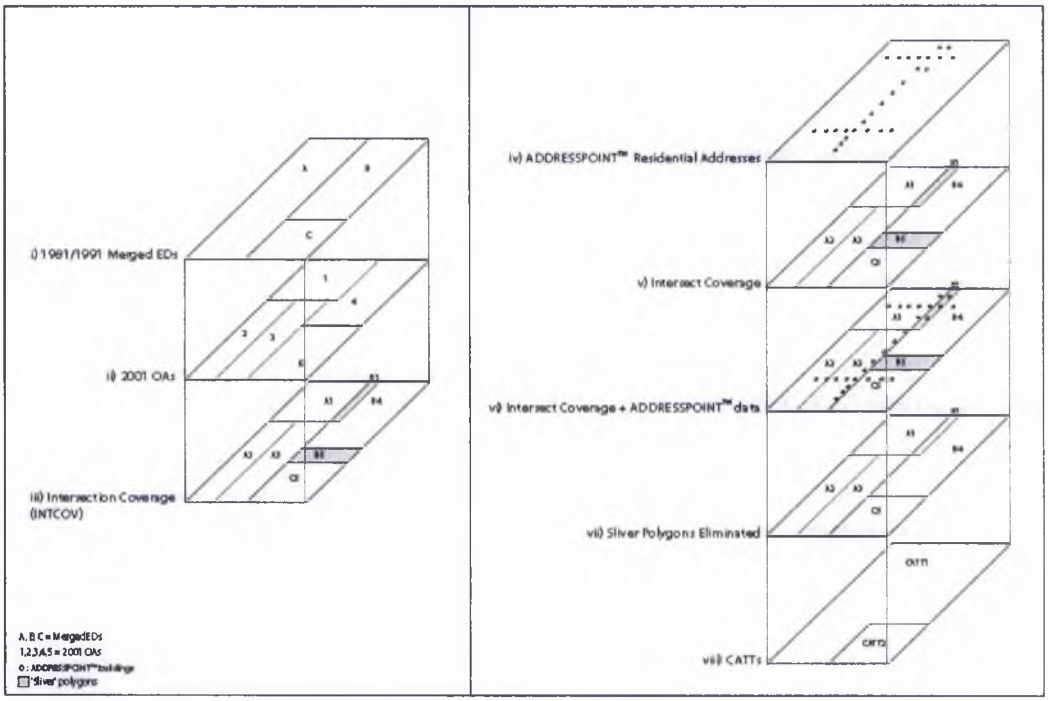

Figure 4-6 A Summary of the steps used to combine Super EDs with 2001 OAs.

The next stage was to remove the polygons that did not contain any ADDRESS-POINT™ data. In ArcInfo, the Eliminate command removes all features from a dataset that meet user-specified criteria. In most cases, the eliminate command merges selected polygons with adjacent polygons that have the largest shared border between them, or that have the largest area (Environmental Systems Research Institute 2003). However, it was possible to programmatically control the elimination process and ensure that the geography of the 2001 OAs were retained.

Referring to the hypothetical example in Figure 4-6iv - Figure 4-6vi, area B1 was identified as a significant sliver which had been designed to reallocate people between areas (this may have occurred because the households in B1 were in the same postcode as households in 2001 OA 1, rather than 2001 OA 4). Conversely, area B5 was identified as a boundary change that did not involve the reallocation of any addresses, and hence could be ignored in our intersection of the 'SUPER EDs' and the 2001 OAs. Thus, in Figure 4-6vii only polygon B5 was deleted since it contained no ADDRESSPOINTS™.

A program was written in the Arc Macro Language (AML) to undertake a 'controlled' elimination of the polygons that did not contain any ADDRESS-POINT™ data points. The AML first associated the arc (line) attributes (records) with the polygon attributes, and the arcs that were part of the 2001 OA boundaries, and the Scottish boundary were given values of –1. Next, the polygons that contained no ADDRESS-POINTs were selected and removed using the Eliminate command. Although there were 54,776 polygons that did not contain any points, the controlled elimination produced a new ArcInfo coverage (MPELIM0) containing 58,030 polygons. Note that in this analysis, a simple file naming procedure was followed. The prefix of the file (e.g. MPELIM) signified that the file resulted from the ELIMINATE process, while the suffix (0) represented the criteria used in the ELIMINATE. In this case, the 0 indicated that all polygons that contained zero (0) ADDRESS-POINT™ data were eliminated. The MPELIM0 coverage included all of the 2001 OAs, but there were 47 SUPER EDs missing because they did not contain any ADDRESS-POINT™ data in 2001. These SUPER EDs were the same as those that were manually allocated to a POSTCODE CATT because they did not contain any postcodes in 2001.

The majority (31,286) of the 2001 OAs fell within a single SUPER ED, but some large 2001 OAs overlapped up to 10 SUPER EDs. To ensure consistency through time, whenever a 2001 OA overlapped more than one SUPER ED, the affected SUPER EDS were aggregated. For example, Figure 4-6vii suggests that one 2001 OA ("1") overlaps 'SUPER EDs' "A" and "B". Thus, these 'SUPER EDs' were aggregated to create one of the CATTs shown in Figure 4-6viii.

A text file containing 56,553 combinations of the SUPER ED and 2001 OA codes was exported from the MPELIM0 file. This included the 47 SUPER EDs that were not included in the MPELIM0 coverage, which were manually allocated to one or more 2001 OA(s). Next, the text file was entered into the Fortran cross-tabulation program to identify the SUPER EDs that would need to be merged so that the 2001 OAs that were overlapping two or more SUPER EDs were accommodated completely within one CATT. This process resulted in 5,875 unique CATTS in the CATT0 coverage, including 64 lochs and water bodies. Loch Ness was originally merged with one of the adjacent CATTs, so this was manually corrected, increasing the number of lochs and water bodies to 65. For this generation of CATTs, all polygons that contained no ADDRESS-POINT™ data were removed in the elimination process, therefore, these CATTs have been called 'CATT0'.

However, there were still 159 CATTs that comprised of more than one polygon, and most of these instances resulted from the lochs and islands across Scotland affecting the configuration of the CATTs. In addition, some of the CATTs comprised two or more polygons that were anchored together at the corners, as described above. While these cases were not considered to be problematic, there were some non-contiguous CATTs created in the CATT0 coverage that needed to be manually corrected. During the elimination process, there were instances such as that shown in Figure 4-7 in which the ADDRESS-POINT™ data were clustered in two non-adjacent parts of the SUPER ED 06AE01 (Figure 4-7a). Note that although there are only two points in Figure 4-7a, these represent tenement housing and between them comprise of 170 addresses. When the SUPER EDs and the 2001 OAs were merged together to create the MPINTCOV coverage (Figure 4-7b), there were only two parts of the SUPER ED that contained ADDRESS-POINT™ data, and therefore the remainder of the SUPER ED was removed. The elimination process resulted in the creation of the non-contiguous CATT '06AE01' (Figure 4-7c).

In these cases, the non-contiguous CATTs were merged with adjacent CATTs, as shown in Figure 4-7d. The SUPER ED boundaries were used as a backdrop when the non-contiguous CATTs were re-allocated, to ensure that the necessary CATTs were merged with adjacent zones that would also ensure consistency through time. Aggregating the necessary polygons resulted in the creation of 5,806 unique CATTs, of which 5,741 could reliably be associated with census data from 1981, 1991 and 2001, and 65 were lochs and water bodies. In the elimination process, the islands and lochs that were included in the 1991 OA coverage but were omitted in 2001 were removed, leaving 65 lochs in the resulting CATTs.

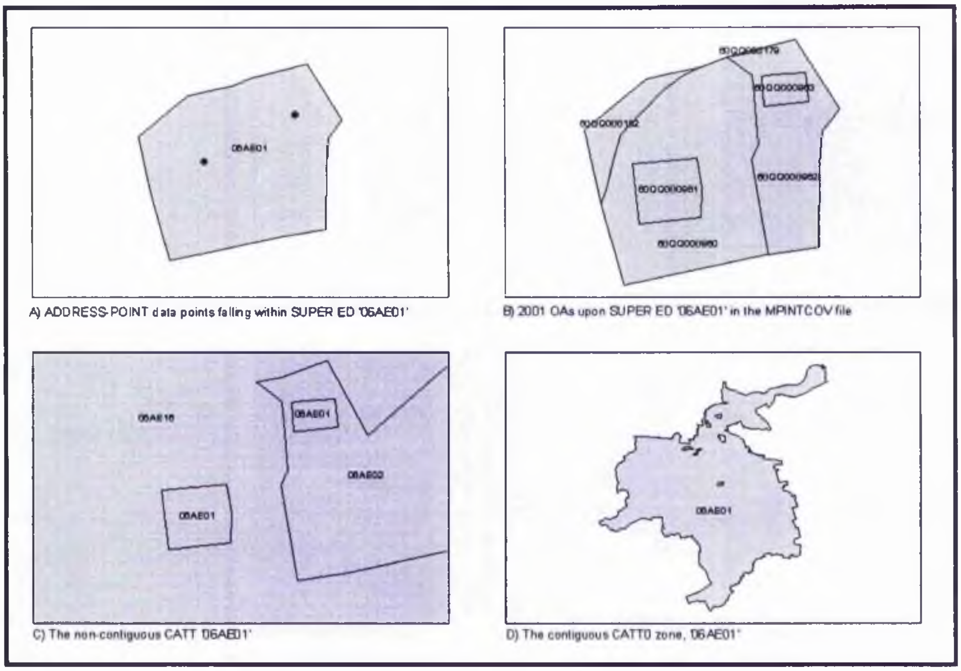

Figure 4-7 Non-contiguous CATTs in the CATT0 coverage resulting from problems created during the elimination stage

The number of unique CATTs in the CATT0 coverage (5,741) was considerably less than the 12,970 CATTs in the POSTCODE CATTs coverage, and there were some considerable differences. First, the CATT0 generation conformed to the criteria that the 2001 OAs must be wholly contained by a CATT boundary. Second, a comparison between the 'central belt' frames of Figure 4-3 and Figure 4-8 demonstrates that the POSTCODE CATTs were smaller and more akin to the configuration of the official small area census boundaries. However, there were obvious boundary changes between 1991 and 2001 that were not captured in the POSTCODE CATTS, but have been accounted for in the CATT0 generation.

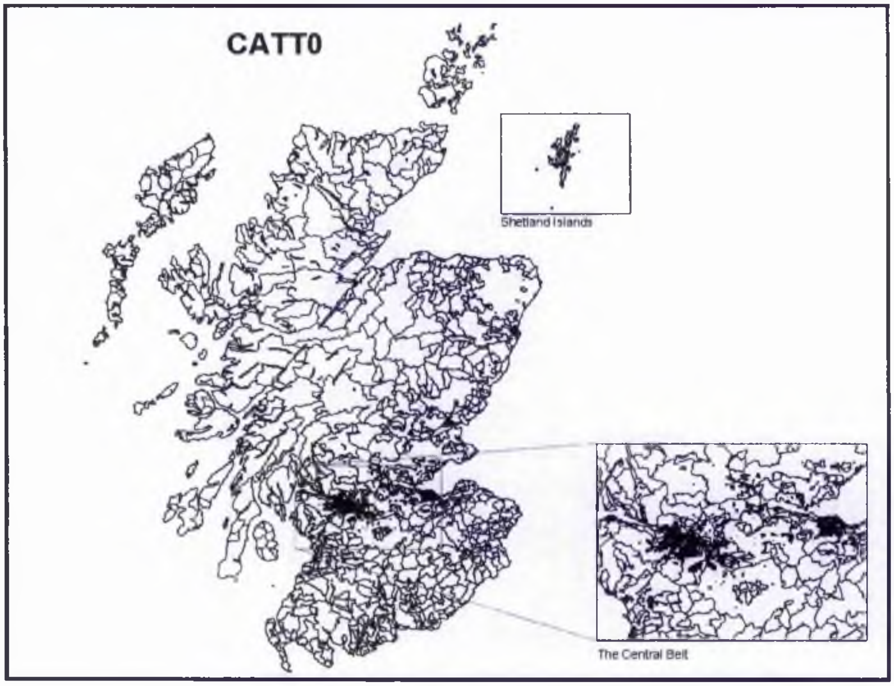

Figure 4-8 CATT0 - the cleanest possible local-area consistent geography for Scotland, 1981-2001

By accounting for the boundary changes, and enforcing a strict rule that any polygon that did not contain any ADDRESS-POINT™ data was treated as a sliver polygon that should be deleted, there were some very large CATTs in the CATT0 coverage. The central belt frame in Figure 4-8 contained an example of a large CATT boundary, to the South East of Glasgow. In total, there were 54 CATTs that had a 2001 population of more than 10,000 in the CATT0 coverage, and one zone covered most of the Fife Council area, with a population of 143,868.

The large CATT0 zone shown in the central belt frame of Figure 4-8 also demonstrates an example of 'Mainland Islands'. Mainland Islands are instances where one or more relatively small CATT(s) is/are surrounded by a much larger CATT, and they occur throughout Scotland. They are more prevalent in rural parts of Scotland, and most likely represent small villages that are surrounded by largely rural landscapes. Mainland Islands also occurred in the CATTs created from postcodes, and in both instances, they represent localities that have not experienced boundary changes between 1981 and 2001.

Descriptive Statistics for CATT0s

The total population for the three time periods of interest have been aggregated to the CATT0 level, and the summary statistics are provided in Table 4-6. In 1981, there was one CATT with the minimum population of 52 (06AS20). There were two CATTs with a population of 51 in 1991 – 06AS20, and 30AK18. There were also two CATTs with 50 residents in 2001 (30AG02 and 41CR34). The CATT 05AC03 had the highest population in each time period. For each time period, the mean population for the CATT0s were more than double the mean of the POSTCODE CATT populations for the same time period. The standard deviations reported for the CATT0 zones were roughly an order of magnitude greater than those observed for the POSTCODE CATTs, indicating that there was much more variation in the population distribution for the CATT0 generation of CATTs.

	Minimum	*Maximum*	*Total*	*Mean*	*Standard Deviation*
1981	52	119,834	5,033,965	876.84	3,387.13
1991	51	132,862	4,998,320	870.64	3,608.97
2001	50	143,868	5,062,011	881.7298	3,906.95

Table 4-6 Descriptive Statistics for the total populations (1981-2001), at the CATT0 level.

The CATT0 generation of the CATTs was the cleanest possible local level consistent geography for Scotland. However, there were some problems with the CATT0 generation. First, there were some very large CATTs, both in terms of population and acreage. Second, the CATTs did not resemble the official 2001 small area geographies. Third, whereas small villages might have consisted of 10 OAs in 2001, it was not uncommon for them to be represented as just one or two CATTs. The worst cases saw entire small villages being merged with a larger neighbouring CATT, which was predominantly rural and contained a comparatively small population.

4.5.2. Constructing CATT1s

In an attempt to resolve these three problems, the methods used to create the CATT0 generation were repeated, but the criteria for identifying the potential sliver polygons was relaxed slightly. In this generation of the CATTs, all of the polygons that contained either zero or one ADDRESS-POINT™ were eliminated. There were 60,871 polygons that fitted this criterion and the elimination process created a coverage containing 51,979 polygons (MPELIM1). All of the 2001 OAs were represented in the MPELIM1 coverage, and only 15,687 SUPER EDs were included. The 52 SUPER EDs that were omitted were manually assigned to the 2001 OAs that overlapped them, and added to a text file for processing in the Fortran cross-tabulation program. The text file contained 51,367 records, and linked all of the SUPER EDs to the 2001 OAs and after the necessary SUPER EDs had been merged, there were 8,681 CATTs created in the CATT1 coverage. Naturally, because of the lochs and water inlets splitting some of the CATTs, there were 218 CATTs that comprised of more than one polygon, and there were 54 non-contiguous CATTs. These non-contiguous CATTs were manually corrected, resulting in 8,588 unique CATTs, and 65 lochs (Figure 4-9).

Relaxing the criteria for identifying slivers from polygons containing no ADDRESS-POINT™ data, to removing polygons containing less than two ADDRESS-POINT™ records increased the number of CATTs by 2,847, excluding the lochs and islands. The improvements made in the CATT1 generation are evident in Figure 4-9. Perhaps most noticeable is the addition of 74 CATTs in the Peterhead area, north of Aberdeen, which was originally represented by a single CATT. Furthermore, the number of CATTs in the central belt increased and many of the rural areas that were originally absorbed into large CATTs have been retained in the CATT1 generation.

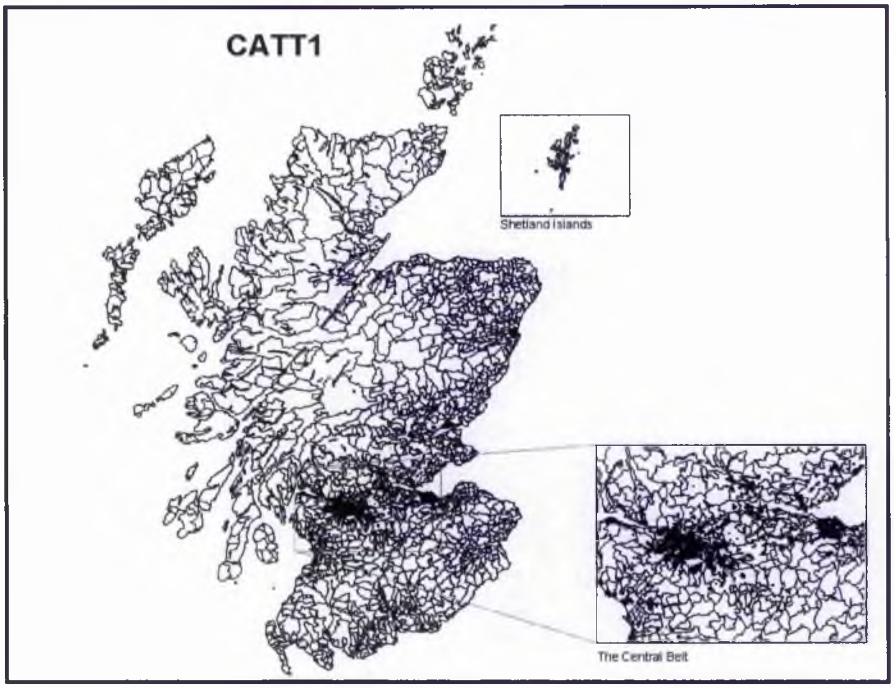

Figure 4-9 CATT1: Created by eliminating polygons with less than two ADDRESS-POINT™ records.

The descriptive statistics for the CATT1 generation are provided in Table 4-7. There was a considerable improvement in the maximum population within a single CATT. Whereas the total populations ranged between 119,834 and 143,868 in the CATT0 coverage, the maximum populations were now less than 36,283. Furthermore, the number of CATT1s that had a 2001 population over 10,000 reduced from 54 to 30 for the CATT1s. For each census, the mean CATT1 population reduced by approximately 300, while the standard deviations improved by about 30 percent, indicating that population in the CATT1s were more evenly distributed than the population in the CATT0s.

Descriptive Statistics for CATT1s

While the summary statistics in Table 4-7 have demonstrated improvements made by relaxing the criteria for eliminating polygons from the MPINTCOV coverage, the results remained considerably higher than those reported for the POSTCODE CATTs in Table 4-5. The maximum populations and the standard deviations for the CATT1 zones are approximately three times greater than those for the POSTCODE CATTs. Similarly, the mean population in the CATT1 zones are approximately 200 more than mean populations in the POSTCODE CATTs.

	Minimum	*Maximum*	*Total*	*Mean*	*Standard Deviation*
1981	52	27,865	5,033,965	586.16	1,045.72
1991	51	32,545	4,998,320	582.01	1,117.49
2001	50	36,283	5,062,011	589.4284	1,274.05

Table 4-7 Descriptive statistics for the total populations aggregated to the CATT1 level (N=8,588).

4.5.3. Constructing CATT2s

Figure 4-9 and Table 4-7 have both demonstrated the improvements made to the CATTs by treating polygons containing a single ADDRESS-POINT™ as sliver polygons. However, there was still a propensity for some zones on the fringes of towns and villages to be merged with their rural neighbours. Therefore, the criterion used in the elimination process was further relaxed so that all polygons containing two or less ADDRESS-POINTs were removed, and the merging process was repeated. Given that 2001 OAs contained a minimum of 20 households, removing polygons containing one or two points was not considered too problematic. Furthermore, it should be noted that an error of two households was still much more accurate than using postcodes, which many other studies have used in the past.

Eliminating the polygons that contained between zero and two ADDRESS-POINTs created a new coverage (MPELIM2) with 49,500 polygons. Once again, all of the 2001 OAs were represented, but because there was a small proportion of SUPER EDs that did not contain any ADDRESS-POINTs, 61 SUPER EDs were initially excluded and were manually allocated to the necessary 2001 OAs. There were 94 OAs from 2001 that overlapped these 61 SUPER EDs.

The text file used as input to the Fortran program contained 49,177 unique records linking the 15,739 SUPER EDs to the 42,604 2001 OAs. The merging process generated 10,181 unique CATT2s, not including the 65 lochs and water bodies. There were 271 multiple-extent CATT2s, but the majority of these were islands, zones split by lochs and water inlets, and polygons that were 'anchored' together. However, there were 61 non-contiguous CATT2s similar to those outlined in Figure 4-7. These non-contiguous CATT2s were merged with adjacent CATT2s.

It should be noted that during this stage, in each generation of the CATTs using the ADDRESS-POINT™ data, when the non-contiguous CATTs were solved, the SUPER ED boundaries were also considered, to ensure that the geography was consistent from 1981 onwards. Once the non-contiguous CATTs were solved, the coverage contained 10,058 unique CATT2s, not including the lochs and water bodies (Figure 4-10).

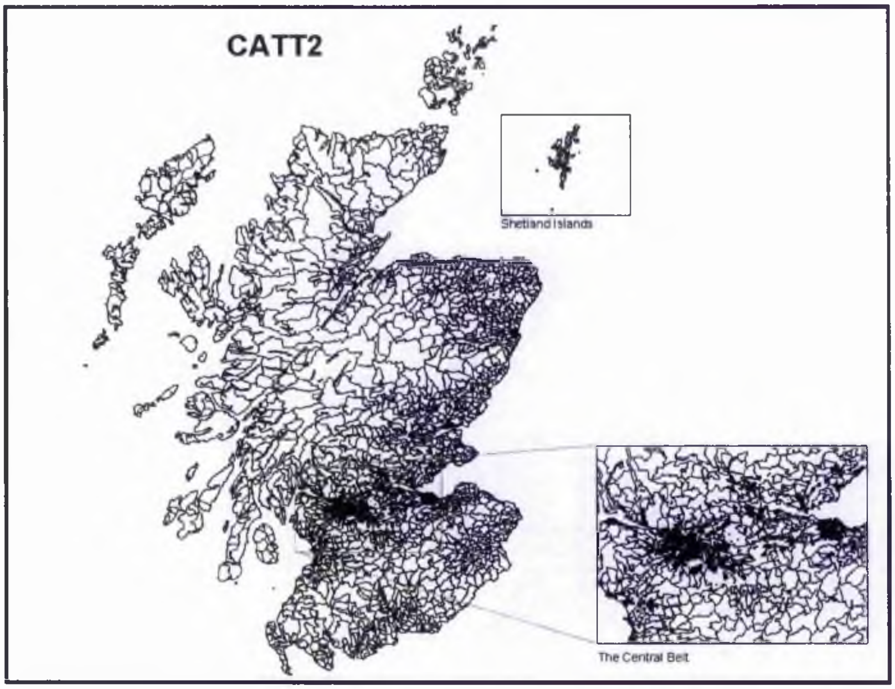

Figure 4-10 CATT2: Created by eliminating the polygons that contained less than three ADDRESS-POINT™ records.

The benefits of relaxing the elimination criterion to exclude polygons containing fewer than three addresses are demonstrated in Figure 4-10, in which many of the rural communities that were 'missing' in the CATT0 generation have been retained. In addition, the overall composition of the CATT2 boundaries more closely resembles the structure of the 1991 and 2001 OA boundaries. Zooming into the central belt demonstrates that there is a strong similarity between the CATT2 generation and the POSTCODE CATTs (Figure 4-3). In particular, many of the CATT2 'clusters', representing more populous places that can be identified in the POSTCODE CATT file, are also evident in Figure 4-10. Therefore, the CATT2 version of the CATTs is recommended for analysing social changes through time.

Descriptive Statistics for CATT2s

Further benefits of the CATT2 generation can be observed from the descriptive statistics for the total census population between 1981 and 2001 (Table 4-8). Originally, the maximum population within a single CATT0 ranged between 119,834 and 143,868, which has been reduced to between 15,659 and 18,510 for CATT2. The maximum population was now more comparable to the population of a 2001 CAS Sector in Scotland, an official aggregation of the 2001 OAs that also has a diverse population distribution.

	Minimum	*Maximum*	*Total*	*Mean*	*Standard Deviation*
1981	52	16,543	5,033,965	500.49	655.10
1991	51	15,659	4,998,320	496.95	700.61
2001	50	18,510	5,062,011	503.28	830.78

Table 4-8 Descriptive statistics for the total population aggregated to the CATT2 level (N=10,058)

Although the reduction in the mean populations between the CATT1 and CATT2 configurations was not as dramatic as those observed between CATT0 and CATT1, the improvements in the standard deviations indicated a better population distribution for the CATT2 coverage. There were only 15 CATT2s with a 2001 population greater than 10,000, a vast improvement on the 54 CATT0s that fitted the same criteria.

As with the POSTCODE CATTs, there were some 'Mainland Islands' in each generation of CATTs using the ADDRESS-POINT™ approach. Figure 4-11 demonstrates that Mainland Islands are clusters of a few CATT2s (dark grey) that were surrounded by a much larger CATT2 (light grey), and were typically located on urban fringes, or in rural locations. In the Highlands of Scotland, there were a number of villages scattered across a very rural landscape, and therefore for small area analyses, the composition of these small villages was retained as often as possible.

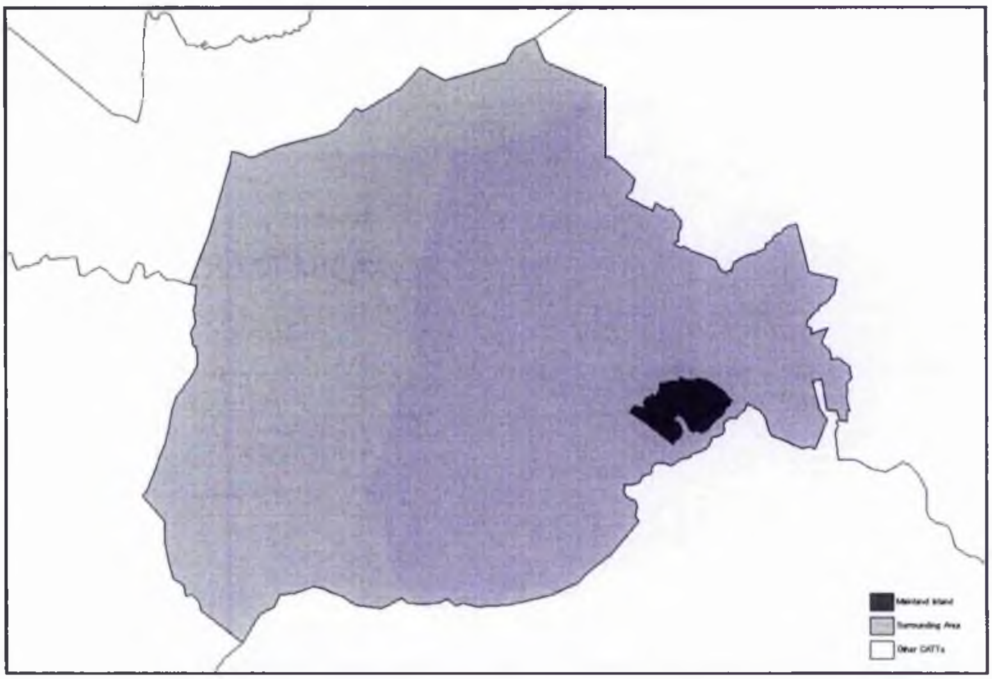

Figure 4-11 An example of Mainland Islands

The Mainland Islands existed because their boundaries did not change through time, and consequently they were kept as unique entities in every generation of the CATTs. Some might argue that a Mainland Island should be merged with the surrounding CATT to create a single zone. However, in many cases, the Mainland Island represented a small town or village that potentially had a different demographic composition to the surrounding CATT and should therefore be preserved. Note that non-contiguity also existed in the 2001 CAS sectors and 2001 CAS Ward boundary files released by GROS, because they used a point-in-polygon process to allocate the 'master postcode' from each 2001 OA to larger geographical areas (See Section 3.4.3).

4.6. CASE STUDY: The total population for CATTs in Fife

During the construction of the CATTs, it was possible that a number of large areas were created, which resulted from a 'daisy-chain' effect during the merging processes. However, as the elimination criteria were relaxed, the number of large CATTs resulting from the daisy chain effect was reduced. The daisy chain effect, and how it was reduced in each generation of the CATTs, can better be understood by focussing in on the Fife Council Area. Figure 4-12 presents the configuration of the three generations of CATTs constructed using ADDRESS-POINT™, for the Kingdom of Fife. In the CATT0 generation (Figure 4-12a), a considerable proportion of Fife belonged to just one zone, with a 2001 population of 143,868. In each part of Figure 4-12 this zone is identified with a bold outline. The large area that this single zone covered reflected the many boundary changes that occurred in Fife between 1991 and 2001.

Therefore, while the CATT0 configuration was the most reliable, because any sliver with a single address was treated as a 'genuine' boundary change, the CATT0s were not particularly practical zones in some parts of Scotland because of the 'daisy chain' effect. There were 247 CATT0s within Fife in the CATT0 generation, with populations ranging from 58 to 143,868 in 2001, and a mean population of 1,614. This compared to the 2,924 2001 OAs in Fife, which had populations ranging from 50 to 562, and a mean of 119.

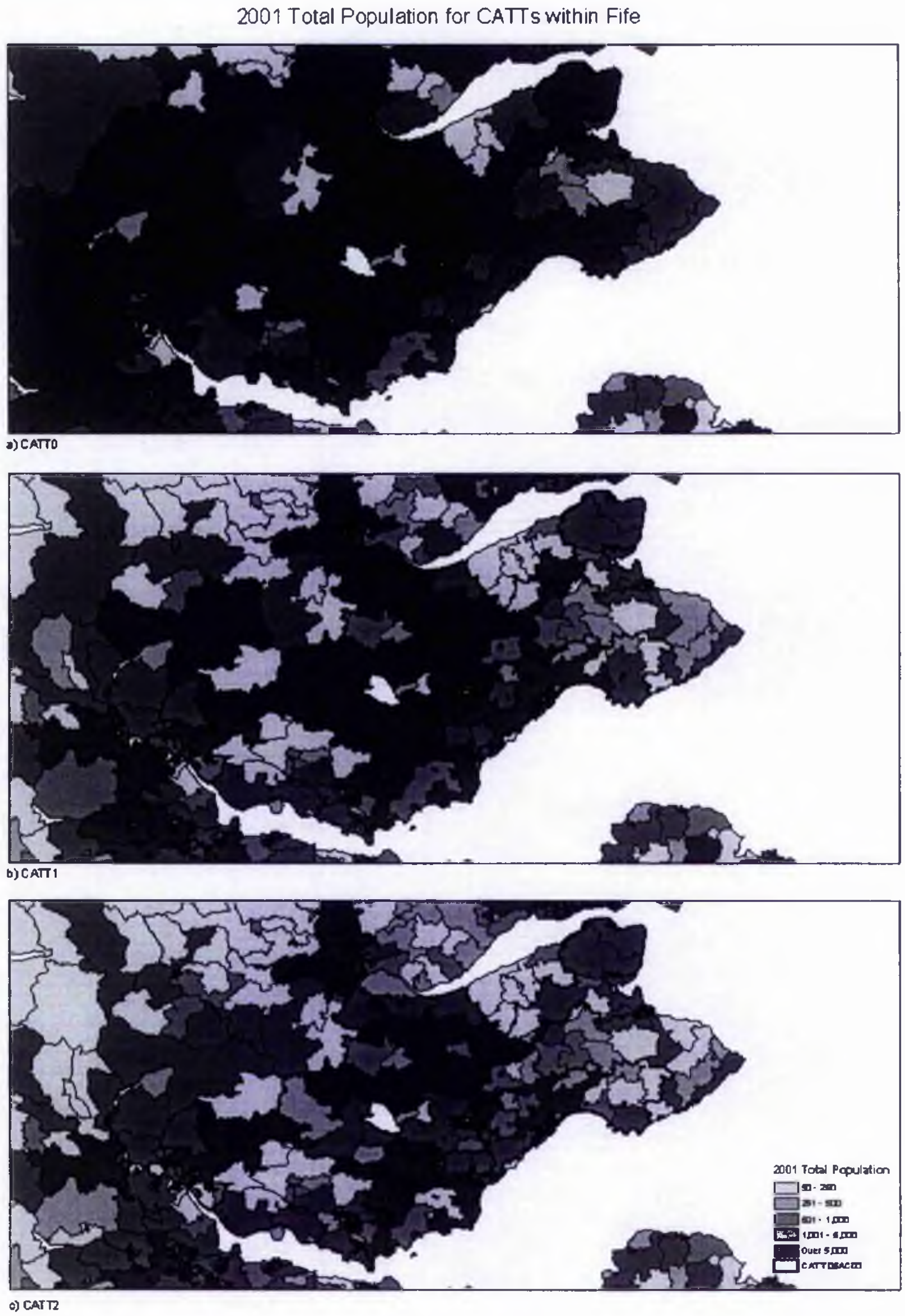

Figure 4-12 The 2001 total population for Fife, aggregated to the ADDRESS-POINT™ - based CATTs

Figure 4-12b demonstrates the improvements to the CATTs obtained by treating polygons that contained one or less points as slivers. The large CATT0 zone discussed in the previous paragraph was split into 107 individual zones.

Furthermore, there were 485 CATT1s in Fife, in which the maximum 2001 population reduced considerably to 36,283 and the mean reduced to 778. The number of unique CATTs increases again to 616 with the CATT2 generation (Figure 4-12c), which had a maximum 2001 population of 18,510 and a mean of 605. The large CATT0 outlined in Figure 4-12a was split into 167 smaller CATT2s in Figure 4-12c.

The population distribution in the CATT2 generation was much more similar to the distribution observed in the 2001 OAs, in which many of the small towns and villages remain scattered throughout the farmland across North East Fife. Thus, since much of the local geography was retained by the CATT2s, it is recommended to use these for analysing social changes through time.

4.7. Linking 1981, 1991 and 2001 data to CATTs

4.7.1. Aggregating small area geographies to CATTs

A number of Geographical Conversion Tables (GCTs) have been created in order to aggregate 1981 EDs and OAs from 1991 and 2001 to each generation of the CATTs. In addition, the 1981 EDs and 1991 OAs can be aggregated to SUPER EDs, but these will not be used in later Chapters of this study. GCTs typically consist of three columns, identifying the 'source' zone (e.g. 1981 ED), the 'target' zone (e.g. CATT2) and a weight (Simpson 2002). For the CATTs however, there was no need for the weight field, since the source zones nested neatly within the target zones. Thus, the aggregation of official small area census data to the CATTs was relatively straightforward.

For some research, aggregation from the CATTs to higher geographies might be required, and a GCT was constructed linking CATT2s to administrative geographies. First, population weighted centroids were created for each of the 10,058 CATT2 zones from the 2001 OAs. However, 32 centroids were manually moved because they fell in the sea or in a loch. Moreover, these errors resulted from problems inherent in the original census data. Second, the 2001 OAs were aggregated into Health Boards, Council Areas, Parliamentary Constituencies, Civil Parishes, CAS Sectors and CAS Wards, using the official Output Area-to-Higher

Areas lookup table, obtained from the GROS. These aggregations were chosen because they were considered by the author to be the most commonly used levels for reporting the demographic composition of Scotland. The summary statistics for these aggregations are provided in Table 4-9.

	Number of Zones	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Health Board	15	19,245	867,150	337,467.40	263,774.64
Council Area	32	19,245	577,869	158,187.84	123,716.51
Parliamentary Constituency	73	19,245	89,311	69,342.62	12,437.54
Civil Parish	862	51	418,317	5,872.40	20,560.83
CAS Sector	1,010	51	20,512	5,011.90	3,441.71
CAS Ward	1,222	652	9,188	4,142.40	1,606.12

Table 4-9 Descriptive statistics for the 2001 higher geographies, derived from the 2001 OAs

Third, the CATT2 grid references were allocated to the higher geographies outlined above, and also to the 1991 administrative Districts, using a point in polygon overlay within ArcGIS. Overall, the CATT2s approximated very well to the higher geographies, particularly for the aggregations that comprised of a small number of zones. Table 4-10 shows that the CATT2s were assigned to every Health Board, Council Area, 1991 District and 2001 Parliamentary Constituency. However, there were fewer approximated Parishes, Sectors and Wards than there were official zones, because there were some CATT2s that overlapped more than one Parish, Sector or Ward. Nevertheless, 95 percent of the Parishes and Sectors, and 99 percent of the official Wards can be approximated from CATT2s.

Table 4-10 also demonstrates that the population distribution of the approximated zones is similar to the distribution for the actual higher geographies. Because the CATTs were not constrained to any higher geography during their construction, it was expected that the population distribution would be quite different to the official distributions outlined in Table 4-9. Surprisingly, the maximum populations for the approximated Health Boards, Council Areas and Parliamentary Constituencies were smaller than the actual 2001 populations for these zones. Although these three aggregations had lower maximum populations, their means were the same as those observed in Table 4-9. In addition, the standard deviation of the approximated Health Boards and Council Areas suggests that there is less dispersion than observed for the official aggregations. Conversely, the more local aggregations – the Parishes, Sectors and Wards, produced much higher maximum populations in Table 4-10 than were reported for the aggregations from the 2001 OAs in Table 4-9. These three aggregations were less resilient to boundary changes than the highest four aggregations, and this was reflected in the descriptive statistics in Table 4-10. For each aggregation, the mean population and standard deviations increased, suggesting greater dispersion than was observed for the comparable official aggregations.

	Number of Zones	*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Health Board	15	19,245	862,873	337,467.40	263,289.33
Council Area	32	19,245	571,607	158,187.84	123,603.19
1991 District	56	11,193	626,498	90,393.10	101,152.98
Parliamentary Constituency	73	19,245	93,780	69,342.62	13,121.42
Civil Parish	817	54	428,579	6,195.85	21,367.93
CAS Sector	959	51	26,166	5,278.43	3,840.47
CAS Ward	1,215	126	23,715	4,166.26	2,579.04

Table 4-10 Descriptive statistics for the 2001 higher geographies, derived from CATT2s.

Although the CATT2-based aggregations were statistically similar to their census-based counterparts, Figure 4-13 highlights that there were subtle differences between the Ward and pseudo Ward configurations. The three 2001 CAS Wards for the St Andrews area are shaded and have a white outline, while the 2001 CATT2-based Wards have black boundaries in Figure 4-13. Thus, the dark grey lines represent instances where a CAS Ward shares the same boundary as a CATT. Figure 4-13 demonstrates that the approximation of the CATTs to Wards was very good, but the match was far from perfect. Consequently, users of the CATT-based aggregations should aggregate data from the CATTs into the required higher geography. The use of incompatible data and boundary files is analogous to the *best-fit whole allocation of source units rather than weighted allocation* error described by Simpson (2002).

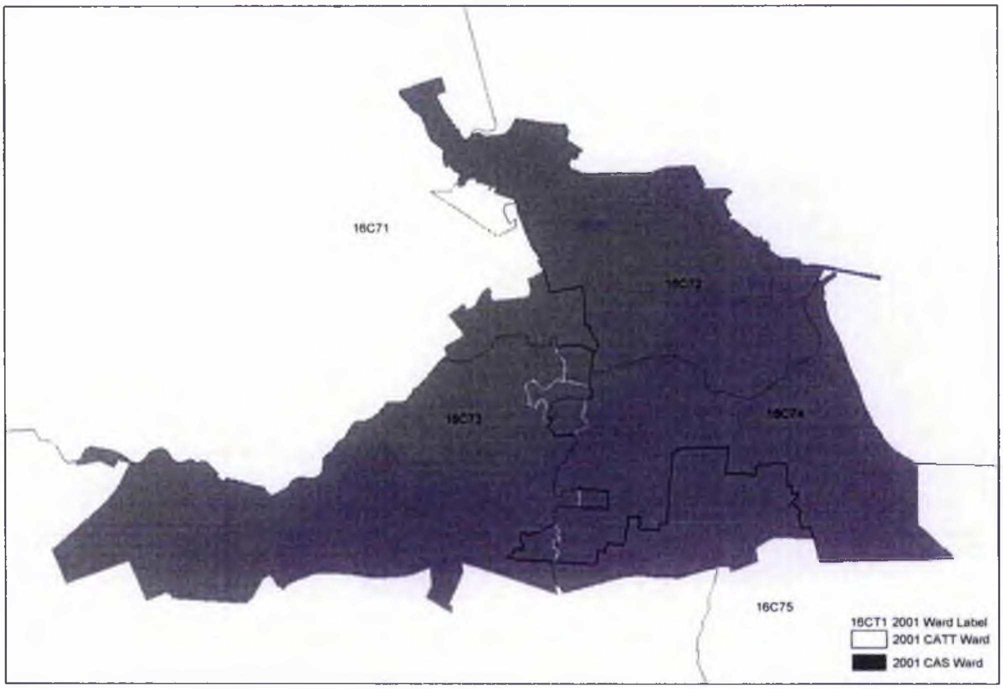

Figure 4-13 The official and CATT-based Wards in St Andrews, Fife.

4.8. Conclusion

A number of approaches exist for creating consistent geographies through time (Bracken and Martin 1995; Flowerdew and Green 1994; Martin 2003; Martin *et al.* 2002; Norman *et al.* 2003; Simpson 2002; Wilson and Rees 1999). However, each of these approaches involves a degree of population estimation and consequently some error results. While Simpson (2002) developed formulae to quantify such errors, this Chapter described an alternative method for creating 'Consistent Areas Through Time' (CATTs). Here, the basic rule was that each CATT should be created from one or more complete 1981 ED, 1991 OA, and 2001 OA. Furthermore, whenever a source zone overlapped more than one target zone, these target zones were merged. This approach was much more accurate than interpolation techniques because the populations derived for each area are based on data from complete census zones (barring, at most, two residential addresses).

For the creation of the CATTs, the 1981 EDs and 1991 OAs were first integrated to create 15,739 SUPER EDs. Next, the postcodes used to create the 2001 OAs were overlain upon the SUPER EDs, and underwent the merging process. Thus, whenever the postcodes belonging to the same 2001 OA were located in more than one SUPER ED, the SUPER EDs were merged to create 12,970 POSTCODE CATTs. However, a visual examination of the POSTCODE CATTs indicated that the postcodes were not an adequate medium for the integration process, because often the 2001 OAs did not nest neatly within the POSTCODE CATT boundaries.

Alternatively, the 2001 OA geography was integrated with the SUPER EDs using a polygon-on-polygon overlay. This inevitably produced a large number of sliver polygons, some of which contained addresses, and some of which did not. It was evident that the postcodes would not be suitable to distinguish between sliver polygons produced from digitising errors, and actual boundary changes between 1991 and 2001. Therefore, help was sought from the GROS, who used the residential addresses in ADDRESS-POINT™ to report the number of residential addresses located within each polygon in the overlay file.

Three sets of CATTs have been developed using the polygon-on-polygon overlay approach, and varied in the way that sliver polygons were handled. The first, CATT0, contained 5,741 data zones, whereby all polygons containing no ADDRESS-POINT™ data were slivers. However, the configuration of townships is compromised due to the merging processes used to create them, and many of the CATT0 zones were very large. The second generation, CATT1, contains 8,588 unique zones, and were produced by removing polygons in the overlay coverage that contained one or less buildings. The CATT1 configuration splits some of the larger zones found in the CATT0 generation, and in doing so townships and settlements become more recognisable. The final generation, and the one that will be used in analyses throughout this thesis, CATT2, contains 10,058 zones and were created by removing polygons from the overlay coverage that contained two or less residential addresses.

The creation of the CATTs means that for the first time in Scotland, census and vital statistics data recorded since 1981 can be compared at a relatively local scale. A series of Geographical Conversion Tables (GCTs), or lookup tables, have been created to facilitate the aggregation of data reported for 1981 EDs, 1991 OAs and 2001 OAs. Since 1981, there have also been many changes to higher geographies, with the exception of Health Boards, (which have remained unchanged since 1974). Thus, to enable reliable analyses at different spatial aggregations, GCTs have been developed to approximate the CATT2s to Health Boards, 2001 Council Areas, 1991 Districts, 2001 Parliamentary Constituencies, 2001 Civil Parishes, 2001 Census Area Statistic (CAS) Sectors and 2001 CAS Wards.

The CATT2s approximated to the complete number of Health Boards, Council Areas, Districts, and Parliamentary Constituencies. However, there are some Civil Parishes, CAS Sectors and CAS Wards that are not approximated by the CATTs because a few CATT2 boundaries overlapped more than one Civil Parish, CAS Sector or CAS Ward. The CATT2s were assigned to higher geographies via a point in polygon query, and using population weighted grid references, thus producing a series of pseudo geographies.

Chapter 2 chapter discussed Scotland's poor mortality record on the international and UK level. Furthermore, Chapter 2 demonstrated that although there were some researchers interested in the spatial distribution of mortality, their research was impeded by the lack of a consistent small-area geography, and was undertaken for relatively large areas. The next chapter uses the CATT2s to investigate the extent to which the mortality gap between the least deprived and most deprived areas in Scotland has widened between 1981 and 2001.

5. The Widening Mortality Gap in Scotland

5.1. Introduction

This Chapter examines the extent to which inequalities in mortality between the least deprived and most deprived areas in Scotland have widened between 1980-1982 and 1999-2001. After a review of existing health inequalities literature, the mortality gaps for the males, females, and the total population across all ages and among for the population below the age of 65 years are examined for 1980-1982 (known as '1981') and 1999-2001 ('2001'). Next, the inequalities between 1981 and 2001 are examined, using a selection of conventional and innovative techniques.

There have been a number of studies that have evaluated the differences in life chances between different sectors of the population. William Farr first used census data to demonstrate inequalities between 'healthy districts' in the 1850s (Farr 1864). More recently, there have been a number of studies investigating the 'widening gap', using a range of indicators to stratify the population including income (Kawachi and Kennedy 1997; Pattussi *et al.* 2001; Blakely *et al.* 2003), occupational social class (Davey Smith *et al.* 1998a; Borrell *et al.* 2002; Emberson *et al.* 2004), and relative deprivation (Carstairs and Morris 1989; McLoone and Boddy 1994; Ben-Shlomo *et al.* 1996; O'Reilly 2002; Singh 2003). Within the UK, due in part to the absence of an income related question in the decennial census, there has been a propensity to use indicators of relative deprivation for health inequalities research. This chapter investigates the relationship between social inequalities and mortality over time. While there is an abundance of research investigating this relationship throughout the world, wherever possible, the examples provided here are drawn from Scotland or Great Britain.

The social gradient in health has been examined using a number of different indicators, a breadth of analytical tools, and a range of spatial scales. Since the 1850s, the social gradient has regularly been evaluated using occupational social class. Occupational social class was pioneered by Stevenson (1923), a Registrar

General, who divided the population into eight classes, based on the results from the 1911 census. His original classification included the five social classes listed in Table 5-1, and three additional classes: VI (textile workers); VII (miners) and VII (agricultural miners). In 1921, social classes VI-VIII were redistributed amongst classes I-V and the five-tiered occupational social class remained relatively constant until 1991.

Social Class		*Example Occupations*
I	Professional	Accountants, engineers, doctors
II	Managerial and Technical	Teachers, marketing management.
IIIN	Skilled-Non Manual	Clerks, shop assistants
IIIM	Skilled- Manual	Carpenters, couriers
IV	Semi-skilled	Tool operators
V	Unskilled	Labourers, cleaners

Table 5-1 Occupational Social Classes used in Britain between 1921 and 2000.

Following a review of national social class classifications, the Institute for Social and Economic Research at the University of Essex developed a new occupational-based socio-economic classification for the Office of National Statistics (ONS). The new classification, known as the National Statistics Socio-Economic Classification (NS-SEC) has been used to identify social class since 2001. The NS-SEC was designed to measure employment relations and conditions of occupations (ONS 2004b, p. 2.) In addition, the NS-SEC was developed to suit a wide range of purposes, and users could derive the NS-SEC at three levels: (full, reduced and simple), as shown in Table 5-2. Unfortunately, the NS-SEC and Registrar General's Social Class were not directly compatible, but it was possible to approximate the NS-SEC to the original social classification.

8 classes	5 classes	*3 classes
1 Higher managerial and professional occupations 1.1 Large employers and higher managerial occupations 1.2 Higher professional occupations 2 Lower managerial and professional occupations	1 Managerial and professional occupations	1 Managerial and professional occupations
3 Intermediate occupations 4 Small employers and own account workers	2 Intermediate occupations 3 Small employers and own account workers	2 Intermediate occupations
5 Lower supervisory and technical occupations 6 Semi-routine occupations 7 Routine occupations	4 Lower supervisory and technical occupations 5 Semi-routine and routine occupations	3 Routine and manual occupations
8 Never worked and long-term unemployed	Never worked and long-term unemployed	Never worked and long-term unemployed

Table 5-2 NS-SEC nestings (Source: ONS 2004a)

The influential Black Report (Townsend *et al.* 1992) made good use of Social Class to demonstrate the inequalities that existed between social class 'I' (SCI) and social class 'V' (SCV). For example, between 1930 and 1972, the standardised mortality ratio (SMR) for males aged 15-64 in SCI decreased from 90 to 75, while during the same period the SMR for SCV increased from 111 to 121. Moreover, when the data were disaggregated to ten-year age groups between 35 and 65 they found that male mortality either was stationery or increased in social classes III, IV and V. By contrast, the mortality rates in social class I and II continued to fall between the 1950s and 1960s.

The Registrar General's social class was based on a male's occupation, and therefore social gradients for females were less appropriate. Often, the patterns for females were restricted to married women, who adopted the social class of their husband. The Black Report used this approach, and identified similar trends for females to those mentioned for males, but in most cases the gradient for women was lower than for men. The authors highlighted the problems associated with this method of inferring the social class of women from their husband upon his wife, noting that a husband and wife that were both in paid employment could have exposure to very different health risks.

The Black Report (Townsend *et al.* 1992) prompted a plethora of research initiatives investigating inequalities for a range of health outcomes. For example, Power *et al.* (1996) used follow-up data from the 1958 British birth cohort to assess the impacts that various social and economic conditions had on social class differences in self-reported health. Using odds ratios and variables representative of health-related behaviour, family structure, working characteristics and material circumstances (observed throughout the life course), they found that no single measure explained the social inequalities observed at age 33. Rather, school qualifications, social class at birth, and psychosocial work characteristics contributed greatly in explaining differences for both sexes. Moreover, for males, other contributing factors included current job insecurity and adolescent smoking. Females, on the other hand, were affected by housing tenure at age 11, age of first pregnancy and also income at age 23. The odds ratios for reporting poor-health status at age 33 were 3.15 for males and 2.30 for women. After controlling for those variables shown to be influential on reporting poor health at age 33, the odds reduced to 2.06 for men and 1.34 for women.

Hattersley (1999) demonstrated the trends in the social gradient of life expectancy for men and women in the UK. She demonstrated that although life expectancy increased between 1972-1976 and 1995-1996, there were marked differences between the life chances of social class I and social class V. On average, men born in 1972-1976 had a life expectancy of 69.2 years, while those born in 1992-1996 were expected to live for 73.9 years. Furthermore, in 1972-1976, men born in social class I were expected to live for 71.9 years, some 5.5 years more than men born in social class V. Despite a number of initiatives aimed at reducing health inequalities being developed following the Black Report, Hattersley (1999) showed that men born into social class I in 1992-1996 could expect to live 9.5 years longer than their peers born into social class V. Moreover, similar social gradients in life expectancy throughout the life course were identified for men and women.

While the use of occupational social class is well established, there are also a number of problems associated with its use in health inequalities research. First, it was not possible to investigate health inequalities for females unless they are married, whereby their social class is inferred from their husbands. Second, the inference approach has become less relevant over the past twenty years as more females have entered the workforce. Third, there are known problems associated with how occupational social class is assigned on death certificates. The problems include the 'upgrading' of the deceased's occupation, for example reporting 'airline *pilot*' rather than 'airline *steward*'. Another problem is associated with the registration of the occupation if the deceased is elderly and has been retired for some time. Therefore, while occupational information is provided on death certificates, it is not always reliable. Fourth, occupational information are not always available for health data, however, a subject's postcode is often routinely collected.

To overcome these problems associated with occupational social class, some researchers have opted to construct a composite index of "deprivation" to stratify the population and identify health inequalities. The definition commonly used in the UK was devised by Townsend (1987), who stated that: "Deprivation takes many different forms in every known society. People can be said to be deprived if they lack the types of diet, clothing, housing, household facilities and fuel and environmental, educational, working and social conditions, activities and facilities which are customary, or at least widely encouraged and approved, in the societies to which they belong" (page 126).

Most composite indices of deprivation have been derived from census data, and have been designed to measure material and social deprivation. For example, the Townsend (1987) Index used the proportion of the population: a) who were unemployed; b) without access to a motor vehicle; c) were living in rented accommodation; and d) were living in crowded households. These four variables were individually standardised and added together to create a composite score. Furthermore, Townsend used a log transformation on the unemployment and overcrowding variables to account for skewed distributions. The overcrowding and tenure variables were chosen to represent lack of access to adequate housing, while the car variable represented the lack of personal possessions. The Townsend index has been regularly used in the analysis of health inequalities in morbidity and mortality.

Of particular interest to Scotland was the construction of the index devised by Carstairs and Morris (1991). Carstairs and Morris also used a composite of four un-weighted and standardised census variables. They used male unemployment, overcrowding, and lack of car ownership, but opted for the proportion of people living in low social class as the fourth variable. In 1981 there was a relatively high number of rented properties in Scotland, and Carstairs believed that this would not be sufficiently discriminatory between areas. In contrast to the Townsend index, the Carstairs Index did not transform the unemployment or the overcrowding variables. Rather, the standardised variables were simply added together to obtain a continuous score. In both indices, the standardised variables have a mean of zero and a standard deviation of one. Thus, a negative score represents areas that are relatively less deprived, whereas an increasing positive value equates to increasing relative deprivation.

The development of deprivation indices such as those above has been the subject of much debate. First, composite indices were criticised for the inclusion of the car ownership variable because people living in rural areas were more likely to require a vehicle out of necessity and consequently it would not be an indication of relative deprivation. By contrast, residents living in urban areas would have better access to public transport and were therefore less likely to require a vehicle. Second, Gordon (1995) criticised the use of equal weightings for the variables included in composite deprivation indices. Given that different sectors of society suffer different degrees (or types) of deprivation, Gordon (1995) argued that the census variables included in the index should be weighted appropriately. Furthermore, using data from the Breadline Britain survey (Gordon and Pantazis 1997), which was designed to assess and identify areas of poverty, he developed an index that estimated the proportion of poor households within an electoral ward. Similarly, Gilthorpe (1995) investigated the impacts that normalisation had on the variables in a deprivation index. His analysis of four alternative transformations to the variables used in the Townsend index confirmed that variables undergoing no transformation produced indices that were distorted by the skewed nature of the input variables, and that such indices would not be consistent across space and through time. Additionally, the types of transformations that were performed on the individual variables affected the composite index. Using individual variables from the New Zealand Census that were included in the construction of the New Zealand Deprivation Index (1996) (Salmond *et al.* 1998), Exeter and Forer (2001) demonstrated how two areas belonging to the same NZDep96 decile could have very different deprivation profiles.

A further criticism of deprivation indices that are derived from census variables was that the variables did not reflect accessibility to resources very well. During the 1990s, much socio-economic data derived from sources other than the census became available to the academic community, such as accessibility to resources, and income-related dimensions of deprivation. This produced a number of deprivation indices that more effectively captured dimensions of deprivation unobtainable from the census. The Department of the Environment, Transport and the Regions (DETR) commissioned the Department of Social Policy and Social Work at the University of Oxford to review the existing measures of deprivation, and update the DETR's original index of local deprivation, which was developed in 1998.

Their review prompted the development of the Index of Multiple Deprivation (IMD 2000) (DETR 2000), a Ward level index that used 33 different variables, each representing one of six dimensions, or 'domains' of deprivation. These domains were income; employment; health and disability; education; housing; and geographical access to services. While many of the existing indices used data from the census to quantify deprivation, the IMD 2000 additionally comprised of data provided by a number of administrative sources. These sources included the NHS, (access to a GP), Local authorities (homelessness); the Department for Social Services (income support); the ONS (comparative mortality ratios); and the University and Colleges Admissions Service (university/college entrance).

Each of the variables within a domain was combined to create a domain index. Each domain index was then standardised and underwent an exponential transformation to ensure that the combined index did not produce misleading results by disproportionately representing various aspects of deprivation. Reflecting arguments regarding the importance of weighting constituents in a composite index (e.g. Gordon 1995), the different domains of the IMD 2000 were weighted based on their robustness. Thus, the Income and Employment domains held the most weighting (25% each). Next, the Health and Disability and Education domains were given 15% weightings each, while the Housing and Geographical Access domains held the least weighting with 10% each.

The IMD 2000 was calculated for each Ward in England and Wales, therefore allowing areas to be compared. For the analysis of overall deprivation, users could compare one area with another, using either the ward's ranking or the overall score. In addition, for any of the six domains, the ward ranking could be used to evaluate the role individual domains had on deprivation in different areas. The same concepts used in the construction of IMD 2000 were used to construct the Scottish Index of Deprivation (2003) (SIMD2003), which was developed by Oxford University for the Scottish Executive (Social Disadvantage Research Centre, 2003), and released in June 2004. The SIMD2003 used the same five domains as the IMD 2000 index, but was specific to Scotland. Glasgow City Council was the most deprived Council Area in Scotland, for all five domains. East Dunbartonshire, which is adjacent to Glasgow City, was ranked as the least deprived Council Area based on the average SIMD score. Similarly, Kearns *et al.* (2000) created a deprivation index for postcode sectors in Scotland. Their index construction was loosely modelled around the IMD 2000 having six domains (housing; crime/environment; health; education; the labour market; and poverty). There were 15 variables spread amongst the six domains, nine of which were derived from the census, while the remaining six were obtained from other administrative sources. Although both the IMD 2000 and the deprivation index for Scotland developed by Kearns *et al.* (2000) responded to criticisms of the traditional indices of deprivation, they have not been widely adopted for health inequalities research.

The methods used to analyse mortality data in health inequalities research vary. The most common approaches to assessing social gradients have been either standardised mortality ratios (SMRs), or age-specific death rates (ASDR). The SMR and ASDR essentially present results for the same data in two different ways, which are dependent on the method of standardisation used in the analysis. In order to be comparable, data from two or more locations and/or time periods must be transformed, using a 'standard' population (Moon *et al.* 2000). Any population could be used as the 'standard', such as the population structure of a particular time period, or of one of the study areas under examination. However, the European and World Standard populations have also been widely used to analyse mortality between countries.

Once the standard population has been decided, age-specific death rates for the total population are calculated by dividing the total number of deaths in each age group by the total number of people in the standard population. Next, given the age-specific death rate for the total population, the 'expected' deaths for each sub-population category (e.g. wards) need to be calculated. There are two methods that can be used to calculate the expected deaths for the sub-population level. For the 'direct' method, the proportions of the standard population in each age group are multiplied by the age-specific death rates of the populations being compared. By contrast, with the indirect method, the age specific death rates for the standard population are applied to the populations of being compared. The number of observed deaths is divided by the number of expected deaths and presented as a percentage.

Roberts and Power (1996) used social class derived from death certificates and age specific death rates per 100,000 to determine whether the overall decline of injury related deaths in childhood (0-15 years) varied across social classes in England in Wales. They found that death rates in social class I improved by 32%, while the rates in social class V only improved by 2%. In addition, by regrouping the social classes into non-manual (I, II, III-non manual) and manual (III-manual, IV, V) it was shown that mortality decreased by 33% for the non-manual group. By contrast, deaths among the manual group decreased by only 17%. The authors found similar trends when they explored death rates for motor vehicle accidents, pedestrian accidents, and fire-related deaths separately. For motor vehicle accidents rates in social class I improved by 30% while the decline in social class V was just 1%. It was suggested that the causes for the worsening mortality gap was due to the different classifications of social class used by the Office of Population Censuses and Surveys (OPCS, now ONS) for 1981 and 1991 mortality data.

SMRs have been regularly used to identify social and geographic differentials in mortality. For example, Fox and Goldblatt (1982) used data from the longitudinal study for England and Wales to demonstrate that between 1971-72 and 1974-75 the SMRs for males dying from all causes in social class I decreased from 105 to 60 while the SMR for men in social class V increased from 111 to 124. They suggested that because the proportion of the contribution to mortality by the individuals who were ill on census day would decrease over time, the social class gradient would increase. In addition to the social class gradient, Fox and Goldblatt (1982) demonstrated relationships between mortality and housing tenure, car ownership and overcrowding.

Drever *et al.* (1996) used male mortality data over the period 1970-72 to 1991-93 and showed that while there was an absolute reduction in mortality, the reduction was not consistent across the social gradient. Moreover, while social classes I-IV experienced regular declines, mortality in social class V increased between 1970-72 and 1980-82 before declining during the 1980s and early 1990s. For all cause mortality, social class V had 3 times more deaths than social class I. While most commentators examine the relative inequalities between the highest and lowest categories, Drever *et al.* (1996) also highlighted the differences between social class I and social class III. The SMR for all cause mortality was 66 for social class I, 116 for social class IIIN and 117 for social class IIIM.

SMRs have often been used in conjunction with deprivation and/or geographical regions to describe social inequalities. Shaw *et al.* (2000a), used deciles of the modified breadline Britain index (Gordon 1995) to demonstrate the increasing mortality differentials in all cause mortality for 15-64 year olds. Using five-year periods between 1981 and 1997 they showed that mortality in decile 1 (highest poverty) was consistently higher than mortality in decile 10 (lowest poverty). Between 1981 and 1997, the ratio between decile 10 and decile 1 increased from 1.6 to 1.9 for the total population. Over the same period, the ratio for males increased from 1.7 to 2.1, while females were somewhat more consistent and increased from 1.5 to 1.7.

Furthermore, Shaw *et al.* (2000a) calculated excess mortality, defined as those deaths that would not have occurred if the entire population had the same mortality experiences as people living in decile 10 areas. In 1981-1985 there were 20.8% excess deaths across the total population, which increased to 24.0% in 1994-1997. The percentage of excess mortality for males increased by 3.9% over the period, to 25.7% while excess mortality for females experienced a slight increase from 19.1 to 21.1%. Nevertheless, these increases were significant, and suggested that the expected impacts of policies targeting health inequalities were not evident in the late 1990s.

Eames *et al.* (1993) used mortality from 1981-1985 and two deprivation indices (Townsend 1987; Carstairs and Morris 1991), and an index of under-privileged areas (Jarman 1983) to assess the relationship between deprivation and mortality, and whether there were any regional variations in the observed patterns. They constructed SMRs for all cause mortality and also examined the relationship for heart disease and smoking-related deaths. They found that variation in mortality for men and women existed, by deprivation and by region. Mortality ratios were higher in the north of England while areas in the South and East of England exhibited lower SMRs. This was similar to the pattern of deprivation, and increasing deprivation was associated with increasing premature mortality. They extended their study by using regression models to create standardised regression effects, which attempted to describe the relationship between a percentage change in mortality and one standard deviation change in the deprivation score. The standardised regression effects demonstrated similar findings to those found for the SMR-based analyses, but the effects were mostly greater for men than for women, except for heart disease where the trend was reversed. For smoking-related mortality, the results from the standardised effects were inconsistent, with greater gradients in the south than in the north. In addition, females exhibited higher standardised regression effects than for men in the North, suggesting that the social gradient for smoking-related mortality was wider for females than for males.

In addition, Eames *et al.* (1993) also identified varying degrees of heterogeneity within a deprivation quintile, as well as between deprivation quintiles. They go on to say that the geographic variations in mortality were not associated with health care services, and provided three explanations for the variations observed. First, they suggested that the correlations between mortality and deprivation were statistical artefacts, because regions that exhibited narrower deprivation ranges typically had lower coefficients. Second, they suggested that deprivation existed in a number of different contexts, thus affecting each region differently. Finally, because their analysis found that deprivation did not fully explain the variation in mortality between regions, they suggested that there were other factors that influenced geographic variations that they had not considered.

Although SMRs have proved to be the method of choice for many analyses investigating social gradients and/or geographic variations, they have also been subject of much criticism. Julious *et al.* (2001) suggest that SMRs are favoured over the ASDRs, particularly for geographical analyses, for two main reasons. First, it was suggested that researchers believe that analyses using the direct method of standardisation can only be represented as a rate, rather than a more easily interpreted ratio, so they tend to adopt SMRs. In fact, the direct method of standardisation can be presented as a ratio, commonly known as the comparative mortality figure (CMF), which was used between 1921 and 1951 in the decennial mortality reports by the Registrar General.

There were differences between the construction of SMRs and CMFs, but they were designed to report the same results (i.e. mortality trends). Whereas SMRs use the formula of observed/expected deaths, the CMF uses the expected/observed deaths. Furthermore, the CMF is calculated with reference to the standard population while for SMRs, the study population is referred to. Despite these construction differences, both measures identified poor health with ratios greater than 1.0, or over 100%.

The second belief that deters researchers from directly standardised death rates was that they cannot be used when small or missing numbers exist amongst sub-groups. However, Julious *et al.* (2001) calculated SMRs and CMFs for 29 Wards in Sheffield using national and local standard populations (separately) as well as the standard errors for each. When the national (England and Wales) population was the standard, the CMFs and their standard errors were consistently higher than the

SMRs. Ranking the Wards by the CMFs or SMRs also produced different results – by up to four places. The Owlerton Ward had a CMF of 143.96 and was ranked 20th, but the SMR was 132.01 and ranked 24th. When the Sheffield population was used as the standard, the difference between the SMR and CMF, as well as the differences between the Ward rankings, decreased.

Jarup and Best (2003) defended the use of SMRs for mapping geographic variations, suggesting that the maps would be misleading only if the structure of the population (by age and/or gender) differed significantly between the areas being compared. Their notions are widely supported, if only indirectly, by the number of academic papers that continue to use SMRs as the unit of analysis to quantify geographic and/or social inequalities (e.g. Brimblecombe *et al.* 1999; Shaw *et al.* 2000a; Singh 2003). Nevertheless, there are alternative approaches that are beginning to be more widely used, such as life expectancy (Hattersley 1999) Years of Life Lost (YLL) (Franzini and Spears 2003; Gunnell and Middleton 2003; Yang *et al.* 2004), and Disability Adjusted Life Years (DALY) (Bradshaw et al 2003; Reidpath *et al.* 2003), particularly when the research is focussed on the burden of a particular disease.

Thus, the evidence for a relationship between mortality and socio-economic inequalities is abundant. While absolute premature mortality has declined over the past 100 years, this section has highlighted a number of various inequalities. First, male mortality is generally worse than for females. Second, regardless of how deprivation is defined, or how the relationship with mortality is analysed, the social gradient is generally evident. The less deprived experience lower mortality than the most relatively deprived. Third, mortality, and socio-economic inequalities are higher in Scotland than the countries with which it was compared – regardless of the spatial scale at which the research was conducted.

The remainder of this chapter examines the relationship between mortality and deprivation in Scotland between 1981 and 2001. Mortality data from 1980-1982 (referred hereafter as '1981') and 1999-2001 (referred hereafter as '2001'), and census data from 1981 and 2001 have been aggregated to the CATT2 version of CATTs for this analysis. Despite their criticism, SMRs have been regularly used to examine the social inequality gradient, and have also been used in this study.

Furthermore, the following analyses investigate the relative inequalities between the least and most deprived sectors of the population, defined by the population-weighted Carstairs index of deprivation quintiles, each containing an approximate population of one million.

5.2. The Mortality Gap in 1981

5.2.1. Total Population – All Deaths

While there has been much attention paid to the social gradient that exists in health (e.g. Townsend *et al.* 1992; Dorling 1997; Shaw *et al.* 1999), Hayes (2004) recently criticised researchers in social and medical geography for treating health inequalities as a dichotomous phenomenon. In his review of relevant literature, Hayes found that very few social geographers and fewer medical geographers discussed the social gradient. Although many researchers have found differing degrees of inequalities between binary groups, such as the social classes (e.g. Townsend *et al.* 1992; Hattersley 1999) or ethnic groups (e.g. Blakely *et al.* 2003), comparatively few papers focus on the differing inequalities that exist between social groups. Furthermore, Hayes (2004) argued that despite an increased awareness of the critical geographies of health (e.g. Kearns 1993; Hayes 1999; Kearns and Moon 2002; Parr 2002), there has been a failure in the ability to specify the *type* of differences between social groups, or to define the forces or pathways that influence inequalities, despite health generally improving over time. It could be argued that research into social networks were attempts to identify such differences between social groups, however, some networks might be considered as health demoting, rather than health promoting. For example, Hayes (2004) cited ethnic nationalism and fascism as networks that might not be considered as 'ideal' social networks for reducing social inequalities. This chapter was not intended to identify such pathways, and the majority of the results presented below are dichotomous, comparing quintile 1 (least deprived) with quintile 5 (most deprived). However, some attention is paid to the variations between quintiles, particularly when unexpected results are identified.

Figure 5-1 presents the SMRs for 1981 and 2001 mortality by population weighted deprivation quintiles (specific to each time period), for all cause mortality; stroke; accidents; heart disease; cancers; respiratory disease; suicides; and all other causes of death. In 1981, mortality was consistently lower in the least deprived quintile than in the most deprived quintile, with mortality in quintile five was 1.46 times greater than the mortality in quintile 1 for all deaths. In addition, Figure 5-1 demonstrates that although the gradient was linear for all eight groups of disease examined (except accidents), the degree of inequalities was not equal. The narrowest mortality gap was observed for stroke mortality (1.30), while the widest gap was apparent for suicides (2.03). Heart disease mortality, which accounted for 29% of all deaths in 1981, was 1.39 times higher in quintile 5 than quintile 1. Similarly, cancers exhibited a mortality gap of 1.45 and the gap for respiratory disease was 1.87 Surprisingly, mortality for accidents was higher in quintile 2 than in quintile 3, but not significantly, and the mortality gap between quintiles 1 and 5 for accidents was comparatively low (1.34).

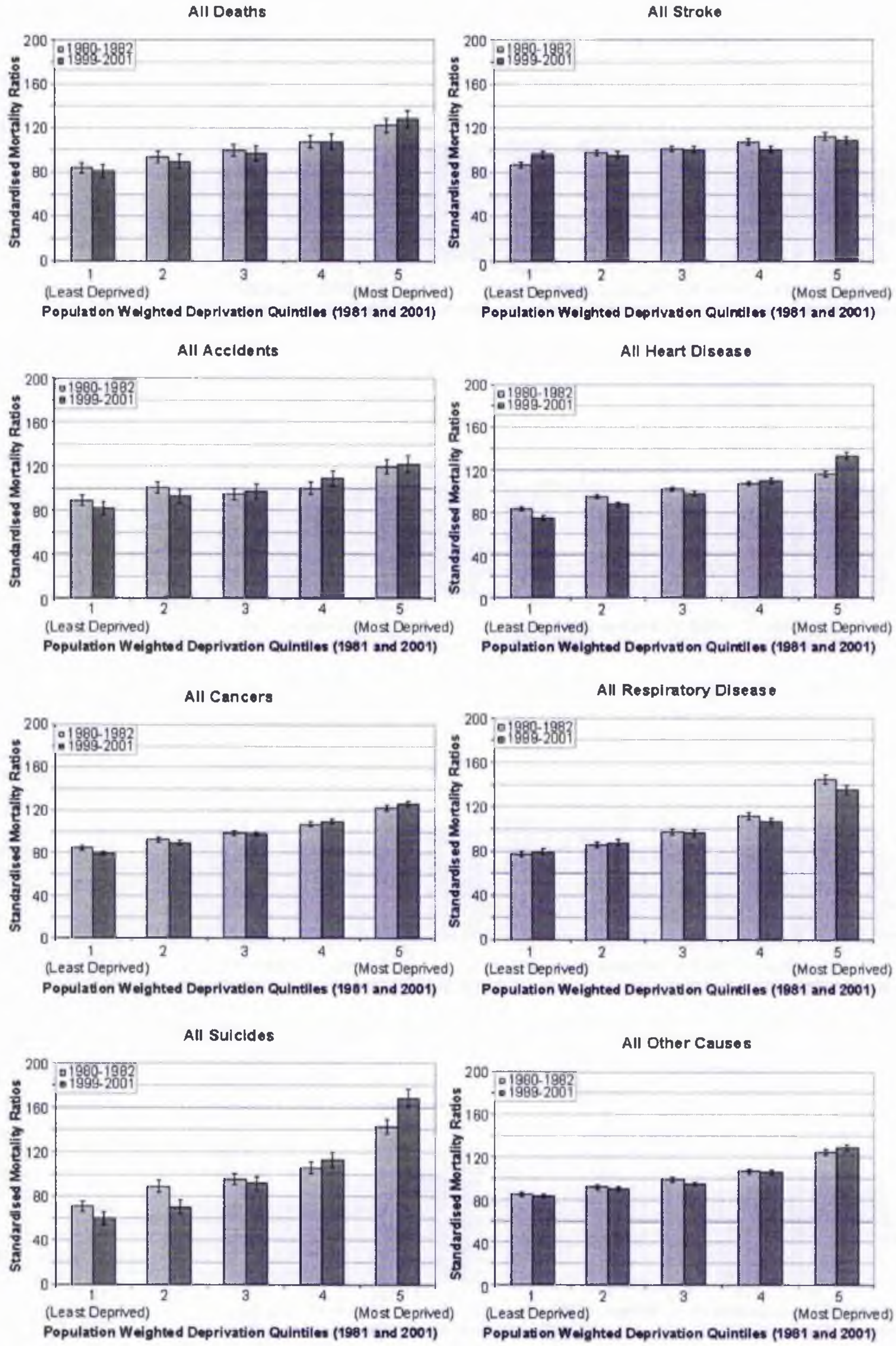

Figure 5-1 The mortality gap (1981-2001) by cause of death

5.2.2. Total Population – Premature mortality

Since Rutstein *et al.* (1976) identified a selection of causes of death that could be prevented or reduced through medical intervention; there has been much interest in the analysis of premature mortality, which focuses on the population aged less than 65 years. Thus, SMRs have been calculated for premature mortality from all causes; and separately for stroke; accidents; heart disease; respiratory disease; cancers; suicides; and all other causes, by population weighted quintiles (Figure 5-2).

The social gradient observed for all cause mortality across the total population was also observed for all premature deaths in the 1981 period, in which the SMR was lowest for quintile 1 and increased for each subsequent deprivation quintile. However, the gradient was more evident for all cause premature mortality than for all-age mortality. Whereas the SMRs ranged from 83.87 in quintile 1 to 122.25 for quintile 5 for all deaths across all ages, the SMRs for premature mortality ranged from 71.36 to 132.71. Thus, the ratio for premature all cause mortality was 1.86.

Similarly, the gradient for premature stroke mortality was more pronounced than for stroke mortality for all ages. The relatively narrow mortality gap (1.30) that was observed for all stroke mortality increased to 1.87 for premature mortality, which resulted from lower SMRs for quintile 1 and higher SMRs for quintile 5. The narrowest premature mortality gap was exhibited by accident mortality, where mortality in the most deprived quintile was 1.55 times higher than for the least deprived quintile, but in this case quintile 2 had a higher mortality rate than quintile 3 and quintile 4.

In fact, the inequality ratio was more pronounced for each group of mortality examined. While suicide mortality was the only cause of death that had an inequality ratio greater than 2.0 for all-age mortality, the greatest premature mortality ratio was for respiratory disease at 3.15. Nevertheless, the social gradient for premature suicide mortality remained, with the SMR for quintile 5 being 2.19 times greater than the SMR for quintile 1. The 'all other causes' group of mortality accounted for approximately 30% of premature mortality in 1981, and had an inequality ratio of 2.09. Although the 'all other causes' had a similar level of inequalities to cancer mortality for all-age mortality in 1981, the social gradient for this group was considerably higher than for cancer mortality, for which the premature mortality ratio was 1.58.

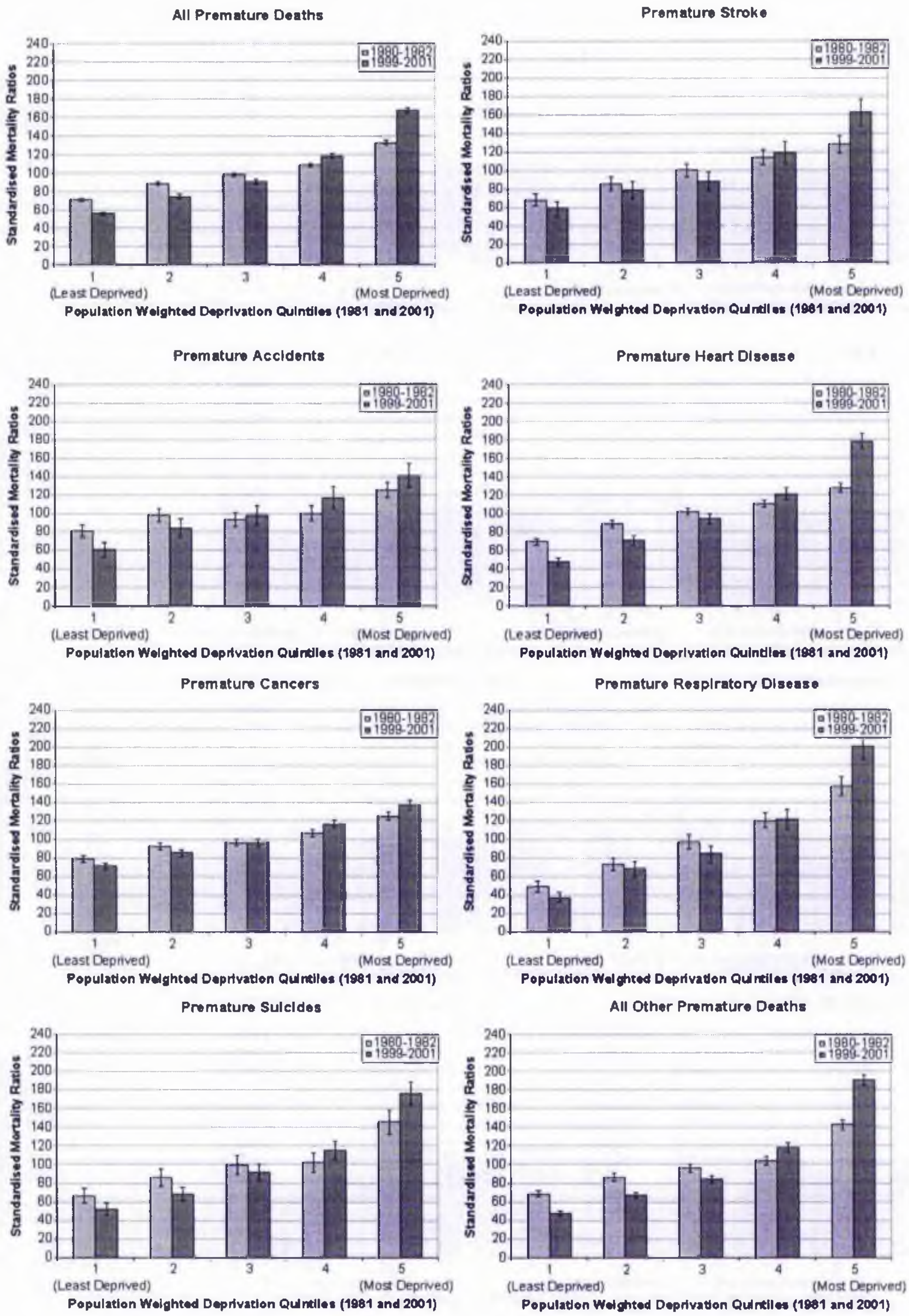

Figure 5-2 The premature mortality gap for 1981 and 2001

5.2.3. Male Mortality – All Deaths

There is much research (e.g. Whitehead 1992; Shaw *et al.* 1999) that has suggested that the social gradient is more marked for males than for females. Thus, SMRs have been calculated for males and females separately, for all cause mortality; stroke; accidents; heart disease; all cancers; respiratory disease; suicides; and all other causes of death; for 1981 and 2001. Figure 5-3 shows the social distribution of mortality by each of these causes for males. As expected, there was a male mortality gradient, in which mortality was lowest for quintile 1 and highest for quintile 5. Moreover, the gradient varied with the different causes of death, and for each cause of death the gradient increased in a stepwise fashion.

The SMR for all cause mortality in 1981 was 1.51 times greater in the most deprived quintile than in the least deprived quintile. The narrowest mortality gap was observed for heart disease, where the SMR for quintile 1 was 84.60 and was 112.41 for quintile 5, with an inequality ratio of 1.33. In 1981, heart disease was the only cause where the mortality gap was lower for males than for the total population. Figure 5-3 shows that the social gradient for stroke mortality (1.35) was similar to that observed for heart disease, which had an inequality ratio of 1.33. While stroke exhibited the smallest mortality gap for the total population, heart disease demonstrated the least polarization for males across all ages. Suicide mortality exhibited the widest mortality gap, where mortality was almost two and a quarter times greater than in quintile 1. The SMR for suicides in quintile 1 was just 66.45, compared to an SMR of 148.29 for quintile 5. For respiratory disease, the mortality gap was 2.02.

5.2.4. Male Mortality – Premature Deaths

Figure 5-4 suggests that the social gradient observed for all male deaths existed for premature male mortality in 1981. For all mortality causes examined, mortality in quintile 1 was significantly lower than the mortality experienced by quintile 5. Surprisingly, the SMRs for premature accidents and cancers were slightly higher for quintile 2 than in quintile 3, however the remaining causes of death demonstrated a step-wise increase in the mortality gradient. Premature male mortality for all causes of death ranged from 70.94 for quintile 1 to 132.40 in quintile 5, resulting in a ratio of 1.87, just 0.01 percent higher than the inequalities observed for premature mortality for the males and females combined.

The male premature mortality gap for accidents (1.55) was identical to the inequalities reported for premature mortality for the total population. Moreover, premature accident mortality demonstrated the smallest mortality gap. By contrast, the widest gap was exhibited by respiratory disease, whereby mortality in quintile 1 was 48.11 compared to an SMR of 150.89 in quintile 5, which resulted in an inequality ratio of 3.14.

The premature respiratory mortality gap was 0.01 higher for males than for the total population. Conversely, the premature mortality gap for males was 8 percent lower than the gap for all premature mortality (Figure 5-2) for stroke mortality (1.78), while the gap for heart disease (1.68) was 17 percent lower than for premature mortality across both sexes combined. By contrast, the male mortality gap was 21 percent higher than the total premature mortality gap for cancers (1.79) and suicides (2.40). The male mortality gap for the 'all other deaths' category (2.11) was also 2 percent higher than the mortality gap for total premature mortality.

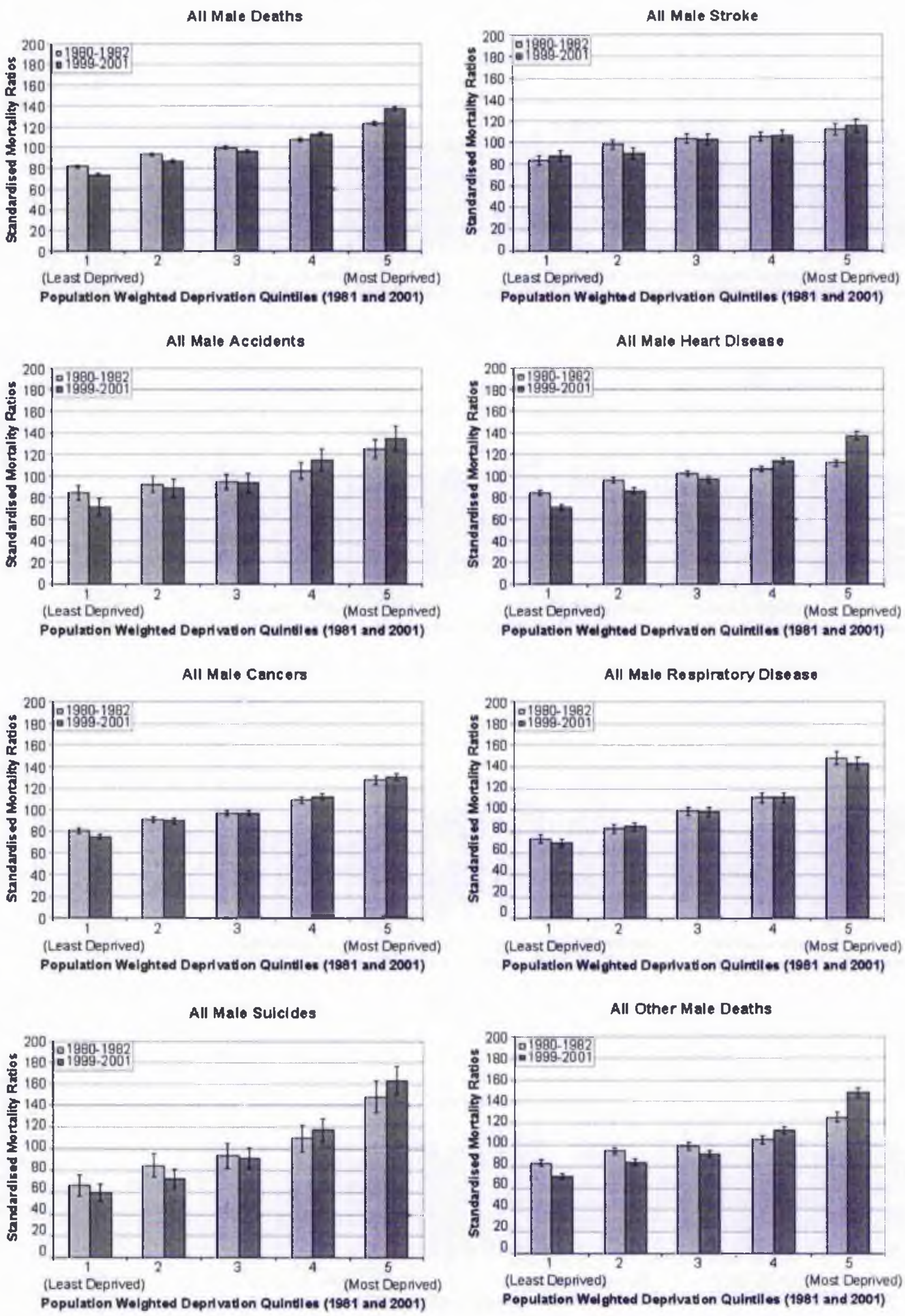

Figure 5-3 The male mortality gap (1981-2001) by cause of death

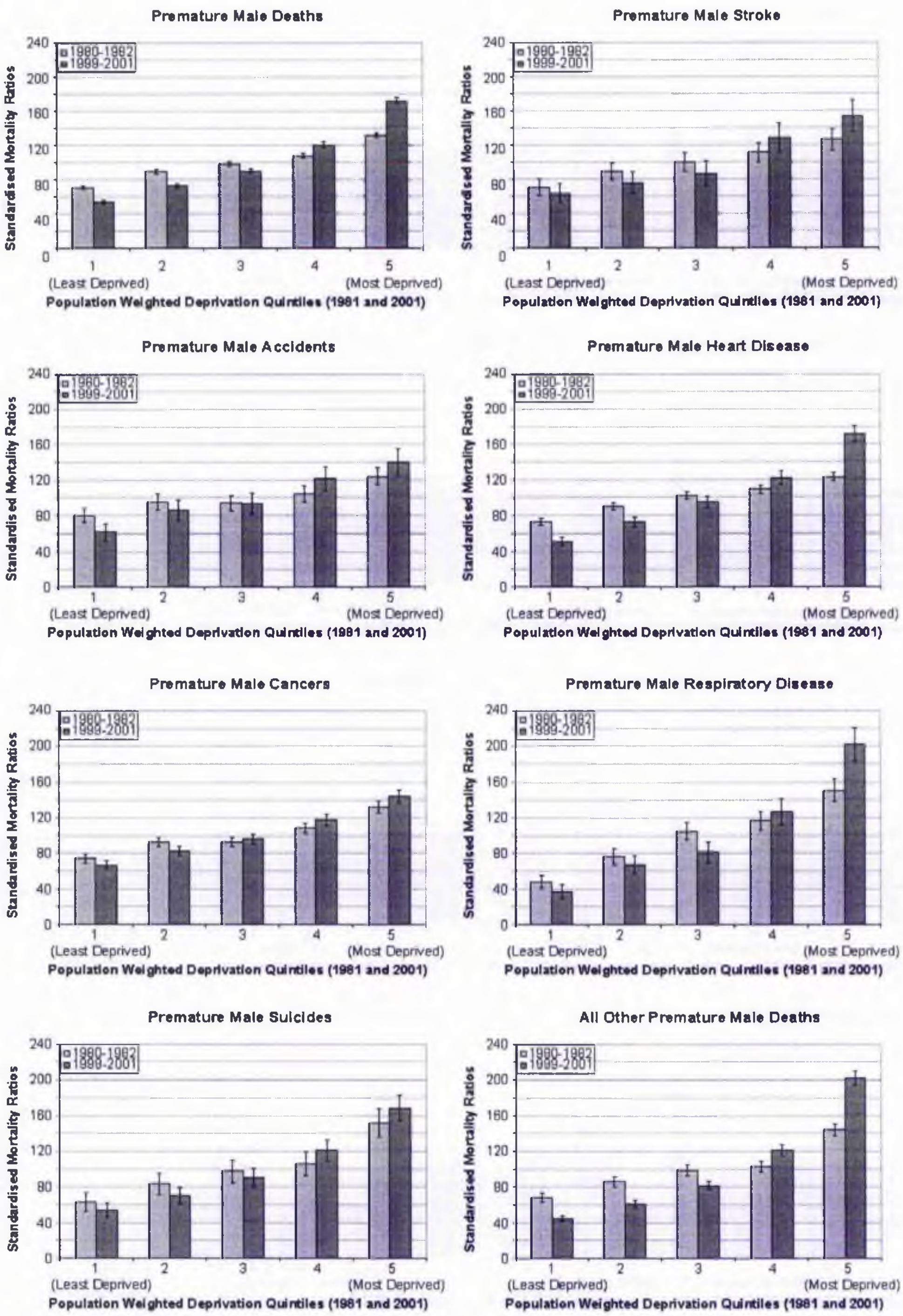

Figure 5-4 The premature male mortality gap (1981-2001) by cause of death

5.2.5. Female Mortality – All Deaths

The mortality gap for all female deaths was shown in Figure 5-5 for all mortality; stroke; accidents; cancers; heart disease; respiratory disease; suicides; and all other deaths. Overall, the graphs suggest that mortality gradients for each of the causes of death were much less pronounced for females than for males (see Figure 5-3). For all cause mortality, the SMR for quintile 1 was 85.81, while the SMR for quintile 5 was 121.14. Thus, the mortality differential for female mortality in 1981 was 1.41, which was notably better than the differential for males (1.51).

Whereas the mortality gap for males ranged from 1.33 to 2.23 in 1981, no cause of death demonstrated an inequality ratio greater than 2.00 for females. Accident mortality experienced the smallest mortality differential (1.18), which was followed by stroke (1.27); cancers (1.32); and then heart disease (1.47). The widest mortality gap was shared by respiratory disease and suicides (1.73). For all other causes, the mortality gap was 1.43.

Although the widest mortality gap was shared by respiratory disease and suicides, they demonstrated contrasting mortality experiences for quintiles 2 through to quintile 4. Respiratory disease increased steadily from 80.80 in quintile 1 to 89.07 for quintile 2; 95.57 for quintile 3; 112.03 for quintile 4 and 140.17 for quintile 5. By contrast, suicide mortality increased from 77.09 in quintile 1 to 95.83 in quintile 2. The SMR for quintile 3 was 98.23 and only increased by 0.50 to 98.83 for quintile 4 before increasing to 133.19 for quintile 5.

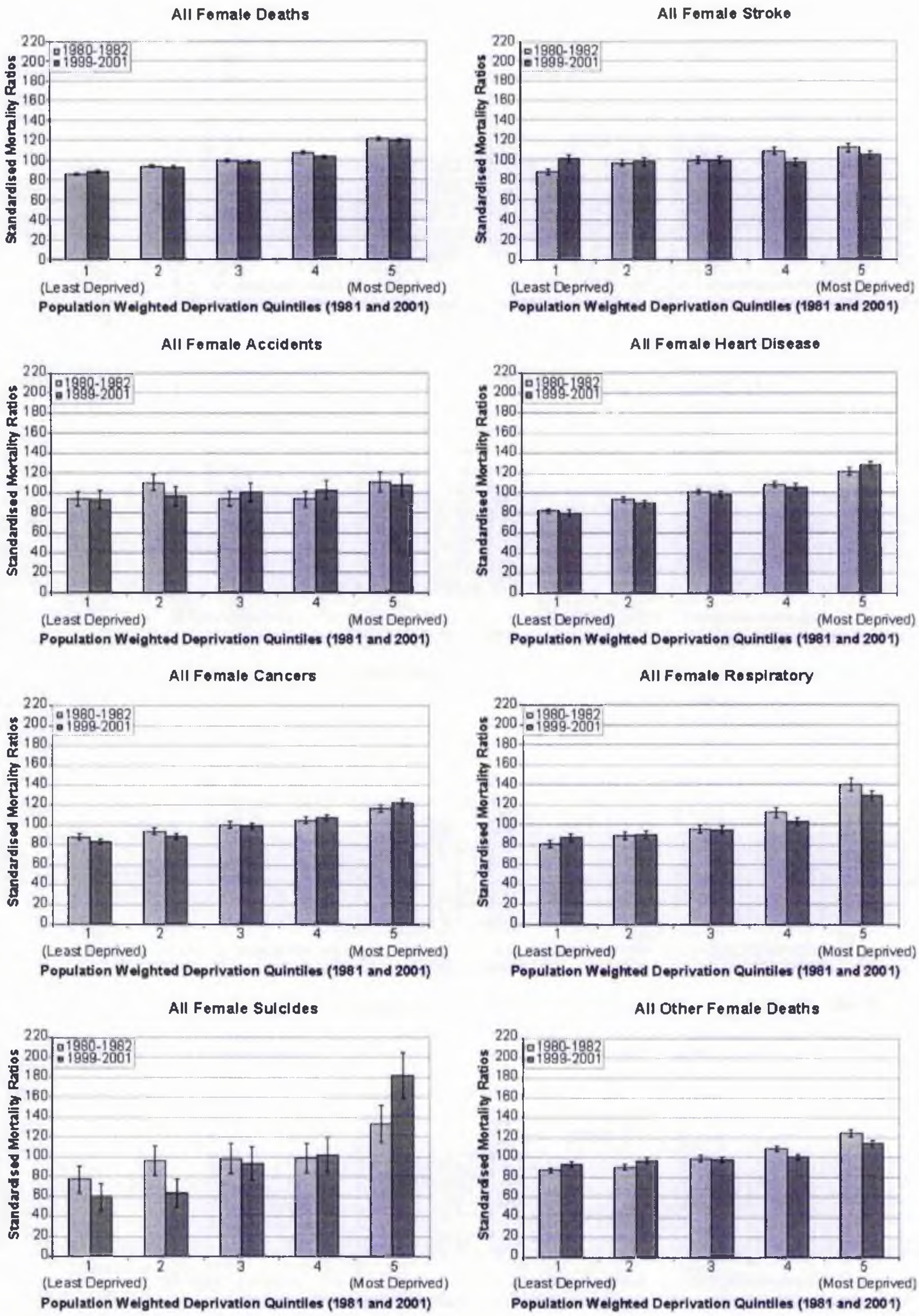

Figure 5-5 The female mortality gap (1981-2001) by cause of death

5.2.6. Female Mortality – Premature Deaths

The premature female mortality gap, shown in Figure 5-6, varied for each cause of death examined. While the SMRs for quintile 1 were always significantly lower than the SMRs in quintile 5, the social gradient between the two quintiles was not consistent for accidents or suicides. Rather, for accident mortality, quintile 2 had the second highest SMR (106.14), and the SMR for quintile 3 (90.32) was slightly higher than the SMR for quintile 4 (87.43), although these differences were not statistically significant. Similarly, for suicides, the SMR in quintile 4 (97.12) was lower than that observed for quintile 3 (104.09) although the difference was not significant.

For the remaining causes of death examined, the social gradient increased steadily from quintile 1 through to quintile 5. For all premature female deaths, the SMR was 1.85 times greater in quintile 5 than for quintile 1. Inequalities in premature female mortality were shown by accident mortality, where, despite its unusual social gradient, mortality in quintile 5 was only 1.55 times higher than in quintile 1. The greatest inequalities were exhibited by respiratory disease mortality with a mortality differential of 3.17, which was slightly higher than the inequalities in male respiratory disease (3.14). The differentials for all cause mortality (1.87), suicides (1.84), cancers (1.38), and the all other causes category (2.06) were less than their respective differentials reported for males in Section 5.2.4 above. By contrast, the inequalities for stroke (1.96), heart disease (2.48), and respiratory disease (3.17) were higher for females than for males.

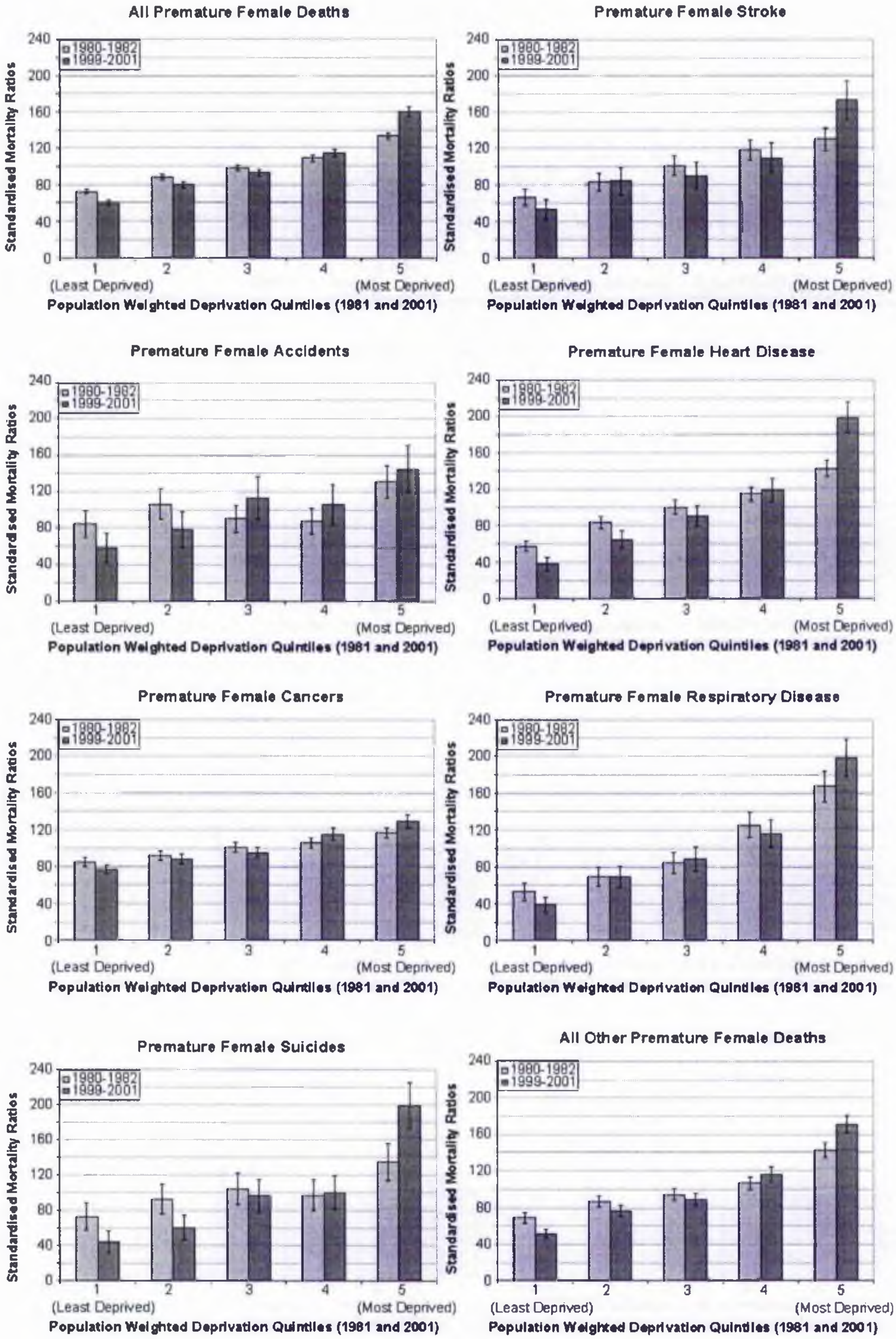

Figure 5-6 The premature female mortality gap (1981-2001) by cause of death

5.2.7. Summary

The preceding paragraphs identified inequalities in mortality between the least deprived and most deprived quintiles in 1981, whilst also highlighting the importance of analysing the mortality data by separate causes of death, and by gender. For example, Figure 5-1 showed that there were 1.46 times more deaths in quintile 5 than in quintile 1. However, the gender specific analyses demonstrated that the inequalities were much higher for males (1.51) than for females (1.41). In addition, the inequalities reported for all-cause mortality (across all three population groups) masked the variable health inequalities that were found for particular causes of deaths, as well as those exhibited by the analyses of premature mortality.

In the analyses of deaths from all ages, inequalities were higher for males than females for each cause of death except heart disease. In contrast, there was much greater diversity amongst the analyses of premature deaths. For example, accident mortality differentials were identical for males and females (1.55), while inequalities in stroke, heart disease and respiratory disease were higher for females than for males. Similarly, inequalities exhibited by males were higher for all cause mortality, cancer, suicides and the group containing all other deaths. Inequalities observed for suicides were consistently high for both sexes and age groups studied.

The ranking of the inequalities observed for deaths at all ages also differed from the rankings found for premature mortality. For example, the narrowest mortality gap was seen in heart disease for males, followed by stroke, accidents, total mortality, all other causes, cancers, respiratory disease, while suicides were the most polarised. In contrast, the male premature mortality inequalities were smallest for accidents, with heart disease, stroke, cancers, total mortality, all other causes, suicides, with respiratory disease demonstrating an increasingly worse level of inequalities. Having identified these variations in the mortality gap for 1981, the analyses have been repeated for 2001, and are reported in the next section.

5.3. The Mortality Gap in 2001

5.3.1. Total Mortality – All Deaths

The mortality gap for 2001 was shown in Figure 5-1, and showed similar patterns to 1981 for all of the causes of death. The gap between quintile 1 and quintile 5 was step-wise for all groups studied, except for stroke mortality, where mortality in quintile 4 was slightly lower than in quintile 3. Nevertheless, the narrow mortality gap observed in 1981 for stroke mortality remained in 2001 (1.13). Similarly, suicide mortality demonstrated the widest gap, as shown in Figure 5-1, where the mortality was 2.82 times worse in the most deprived areas than in the least deprived areas. Despite a reduction in the total number of deaths over the twenty-year period, the mortality gap remained above 1.49 for all types of death studied, except stroke mortality, whose inequality ratio was 1.13.

While it could be expected that the mortality gap would change over time, it might also be expected that the ranking of the inequalities would remain constant over the same period. For example, in 1981 inequalities were lowest for stroke, then widened for accidents, heart disease, cancers, respiratory disease, and suicides. For 2001, stroke mortality had the narrowest mortality gap, followed by accidents, cancers, respiratory disease, heart disease and suicides. Thus, the *ranking* of the inequalities changed between 1981 and 2001, with the biggest shift demonstrated by heart disease, moving from third lowest in 1981 to second highest in 2001. Moreover, heart disease inequalities widened, despite a substantial reduction in the absolute number of these deaths between 1981 and 2001. Heart disease mortality in quintile 1 was 75.13, while the SMR for quintile 5 was 133.13, resulting in a mortality gap of 1.77. Similarly, note that although the cancer mortality gap was ranked lower in 2001 than in 1981, it does not suggest that the mortality gap had narrowed over time. Rather, the inequality ratio for cancer increased from 1.45 in 1981 to 1.60 in 2001.

5.3.2. Total Mortality – Premature Deaths

The inequalities observed for the 1999-2001 ('2001') premature mortality data were shown in Figure 5-2. The SMR for premature deaths from all causes in 2001 was 56.08 for quintile 1, and increased steadily by approximately 20 percent for quintiles 2 (74.92), quintile 3 (91.00) and quintile 4 (118.46), before increasing significantly to

167.69 in quintile 5. Therefore, in 2001, premature mortality from all causes was almost three times (2.99) times higher for the most deprived quintile compared to the least deprived quintile.

For each cause of death, Figure 5-2 demonstrated how the mortality gradient increased in a linear, step-wise fashion and was more prominent than was observed for the 1981 premature mortality analyses. Premature cancer mortality was the only cause of death that exhibited an inequality ratio less than 2.00. Nevertheless, cancer mortality was still 1.92 times higher in quintile 5 than in quintile 1. Moreover, the ratio of inequalities was only less than 3.00 for three causes of death – cancers, accidents (2.32) and stroke (2.77). The premature mortality gap continued to be worst for respiratory disease, where the ratio was 5.33 in 2001.

5.3.3. Male Mortality – All Deaths

The mortality gap for males in 2001 was shown in Figure 5-3. For each cause of death, as the quintile increased so too did the SMR. All cause mortality was 1.88 times higher in the most deprived quintile than the mortality experienced by quintile 1. The narrowest mortality gap was experienced by deaths from stroke (1.32), which was followed by all cancers (1.74); accident mortality (1.89); heart disease (1.97); respiratory disease (2.06) and all other causes (2.09); while the widest gap was demonstrated by suicide mortality (2.74).

For each cause of death except suicides, the differential between quintile 1 and quintile 5 was higher for males than for the total population. For example, the ratio of inequalities was 1.55 for the total population for the 'all other causes' category, but was 2.09 for males. Similarly, the accident mortality differential was 1.49 for the total population but was 1.89 for males.

5.3.4. Male Mortality – Premature Deaths

Figure 5-4 showed that the 2001 premature mortality gap for males was more consistent than for 1981. The inequalities ratio for all male premature deaths was 3.19, significantly higher than the inequalities reported for all male deaths (1.88). Furthermore, no cause of death studied had a mortality gap less than 2.00 in 2001.

Cancer mortality demonstrated the smallest gap, where the SMR for quintile 5 was 2.17 times higher than the SMR for quintile 1. The mortality gap for premature male mortality from accidents (2.27) and stroke (2.42) were the only other causes of death that were less than 3.00. The premature mortality differential for male suicides was 3.13 and for heart disease the gap was 3.37. The widest inequalities were portrayed by respiratory disease, where the SMR for quintile 1 was just 36.98, which was contrasted with 201.94 to produce an inequality ratio of 5.46. Although the inequalities portrayed by Figure 5-4 were dramatic, only two causes of death (cancers and respiratory disease) exhibited a higher degree of inequalities than was shown for all premature deaths (Figure 5-2).

The inequalities observed for male premature mortality were notably higher than for all male deaths. While suicides exhibited the widest gap of 2.74 for all male deaths, Figure 5-4 suggested that the premature mortality gap was most extensive for respiratory disease at 5.46. Moreover, the ranking of inequalities varied between all male deaths and premature male mortality. For example, cancer mortality had the third lowest ratio for all males, but was the lowest for premature mortality. Similarly, suicides moved from being the most polarised cause of death for all men, to having the fourth lowest premature mortality ratio, and was replaced by respiratory disease as the most polarised cause of premature mortality. Unfortunately, the differences in the ranking of inequalities did not signify a smaller mortality gap, and all of the premature mortality ratios were substantially higher than their all-age mortality counterparts.

5.3.5. Female Mortality – All Deaths

Figure 5-5 reported the social gradients for female mortality in 2001. For deaths from all causes, the mortality differential was 1.36, 0.52 less than the differential for male all cause mortality. As expected, the SMRs for quintile 1 were lower than the SMRs in quintile 5 for all causes of death studied. However, the SMR for female stroke mortality in quintile 1 was greater than for quintiles 2, 3 and 4, and was just 3.71 percent lower than the SMR for quintile 5. Thus, stroke mortality demonstrated the narrowest mortality gap for females in 2001, with an inequalities ratio of 1.04.

The mortality gap for the other causes of death were all below 1.60 in 2001, except for suicide mortality, which was more than three times higher in the most deprived than the least deprived quintile and consequently showed the widest inequalities. Between quintile 1 and quintile 4, the SMRs for suicides ranged from 59.46 to 101.94, however there was a significant increase to 181.92 in the SMR for quintile 5.

5.3.6. Female Mortality – Premature Deaths

The inconsistent social gradient shown for female premature mortality in 1981, shown in Figure 5-6, remained in 2001. Premature female suicide mortality was more stable in 2001, although there was an absolute difference of 3.36 between the SMRs for quintile 3 (96.34) and quintile 4 (99.70). Note that there were only 1,662 premature accidents and 2,242 suicides registered for females in the 2001 period, which resulted in considerably wide confidence intervals for these causes. Nevertheless, the SMRs for quintile 1 and quintile 5 were significantly different for both causes.

Premature cancer mortality portrayed the narrowest mortality gap in 2001, where the SMR of 129.02 in quintile 5 was 1.68 times higher than the SMR (76.88) for quintile 1. Accident mortality had the second lowest mortality differential (2.49), followed by all cause mortality (2.68); stroke (3.25); all other causes (3.33); suicides (4.48); respiratory disease (5.17). Premature heart disease mortality experienced the widest mortality gap in 2001. The SMR for premature heart disease in quintile 1 was just 38.08 compared to a SMR of 198.77 for quintile 5, resulting in a mortality differential of 5.22.

The female premature mortality differential was higher than the male premature mortality differentials for stroke, accidents, heart disease, and suicides. This resulted from mortality in quintile 1 being lower, and the SMRs in quintile 5 to be higher for women than for men. Conversely, the SMRs were higher for females than for males in quintile 1 but lower for females in quintile 5 for all cause mortality, cancers, respiratory disease and the all other deaths category.

5.3.7. Summary

In summary, this section has demonstrated that the mortality gap remained in 2001. As was shown in 1981, the gap for premature mortality was substantially higher than the corresponding gap reported for all age mortality. For example, the mortality gaps ranged from 1.04 for stroke to 3.06 for suicides for all female deaths, while the female premature mortality gaps ranged from a 1.68 for cancers to 5.22 for heart disease. However, it should be noted that the suicide inequalities was an extreme case, and all other causes of death examined were less than 1.68 for all female deaths. In contrast, cancer mortality was the only female premature mortality gap that was below 2.00.

The inequalities reported for suicide were not always the widest for a particular age or sex group. However, they were of interest because suicide was the only cause studied that experienced an increase in the number of deaths between 1981 and 2001. Respiratory disease also exhibited a worrying level of inequalities, with males and females (separately and combined) reporting premature mortality gaps of at least 5.17.

For all-age mortality, the differentials were higher for males than females for each cause of death except suicides. However, the results for premature mortality were more evenly distributed. Males reported a wider mortality gap than females for all cause mortality, cancers, respiratory disease and the group representing all other causes. Conversely, females showed the widest inequalities for stroke, accidents, heart disease, and suicides. Thus, in 2001 the distribution of inequalities varied to a greater extent than in 1981.

The social gradient shown for female stroke mortality in Figure 5-5 highlighted one of the problems with ratio-based analyses. In this case, the ratio of inequalities between quintile 1 and quintile 5 was 1.04. Although the most deprived quintile reported the highest SMR for female strokes, the lowest mortality was not experienced by quintile 1. Rather, quintile 4 had the lowest SMR for female strokes in 2001. This supports Hayes' (2004) argument of the increased need for researchers to investigate the *gradient* of inequalities across the population, and not simply take the health experiences reported for quintiles 1 and 5 (for example) as the definitive pattern of inequalities in health.

5.4. The Widening Gap I: Period-Specific Quintiles

The analyses presented in Sections 5.2 and 5.3 have shown that social inequalities existed between males and females, and between the causes of death that were investigated. However, the extent to which the mortality gap changed between 1981 and 2001 has not yet been discussed. There is an abundance of literature that has demonstrated a widening gap for a number of different health outcomes (Carstairs and Morris 1989; McLoone and Boddy 1994; Shaw *et al.* 1998; Hanlon *et al.* 2001; Leon *et al.* 2003), and in many studies the case for Scotland has been considerably bad. For example, Shaw *et al.* (1999) examined patterns in mortality, unemployment, education and income, and found showed that parliamentary constituencies in and around Glasgow were consistently identified amongst the worst in Britain.

This Section focuses on the widening social inequalities in Scotland between 1981 and 2001. Since the Black Report (Townsend *et al.* 1992), there have been a number of initiatives developed by local and central governments to combat social inequalities. Therefore it would be expected that the inequalities in mortality should have decreased over time. To quantify the changing patterns of mortality over time, the mortality differentials reported for each cause of death in 1981 have been compared to the corresponding mortality differentials for 2001.

5.4.1. Total Mortality

The mortality differentials between quintile 1 and quintile 5 for 1981 and 2001 are provided in Table 5-3. In addition, the difference in the mortality ratios (the absolute change), and the relative differences in the mortality differentials (ratio change between the two ratios) have also been provided. If the social inequalities have narrowed over the twenty-year period, the value of the absolute change will be negative, while the ratio change will be less than 1.00. Therefore, Table 5-3 demonstrates that the absolute mortality gap for all cause mortality increased by 0.12 from 1.46 in 1981 to 1.58 in 2001. In addition, the ratio change of 1.09 for all cause mortality indicates that the relative mortality gap widened over the period.

While inequalities in all cause mortality widened, Table 5-3 shows that inequalities reduced for two causes of death. The narrowest mortality gap in 1981 and 2001 was for stroke. In addition, as the mortality differential declined by 0.16 in 2001, stroke mortality also demonstrated the lowest ratio change of 0.87. Thus, there was a 13 percent relative improvement in inequalities for stroke mortality. Respiratory disease was the only other cause that exhibited a reduction in the mortality gap, which was 0.91 lower in 2001 than 1981.

Cause of Death	*Quintile 1:Quintile 5 1981*	*Quintile 1:Quintile 5 2001*	*Absolute Change*	*Ratio Change*
All Causes	1.46	1.58	0.12	1.09
Stroke	1.30	1.13	-0.16	0.87
Accidents	1.34	1.49	0.15	1.11
Heart Disease	1.39	1.77	0.38	1.27
Cancers	1.45	1.60	0.14	1.10
Respiratory	1.87	1.71	-0.17	0.91
Suicides	2.03	2.82	0.79	1.39
All Others	1.46	1.55	0.09	1.06

Table 5-3 The changing ratio between the SMRs for all deaths in the least and most deprived quintiles in 1981 and 2001, by cause of death

Suicides demonstrated the widest inequalities in 1981 and 2001 and also showed the largest increase in inequalities over time, with an absolute increase of 0.79. Moreover, the ratio change of 1.39 indicated that the effect of deprivation increased over the period. Figure 5-1 showed that the SMR for suicides reduced from 70.39 in 1981 to 59.58 in 2001. In contrast, the SMR for quintile 5 increased from 142.86 in 1981 to 168.29 in 2001.

Although the absolute number of deaths relating to heart disease decreased by some 16,200 over the study period, the inequalities widened substantially. In 1981, the mortality gap between quintile 1 and 5 for heart disease (1.39) was the third lowest of the causes studied here. However, in 2001, the gradient had increased in absolute terms by 0.38 and by 27 percent in relative terms. A comparison of the 1981 and 2001 data for heart disease in Figure 5-1 emphasizes that the mortality reduced for quintile 1 but mortality in quintile 5 increased extensively.

5.4.2. Total Premature Mortality

Any rise in the mortality gap should be considered unacceptable, however, the increasing mortality differentials outlined in Table 5-3 are relatively modest when compared to the widening mortality gap shown for premature mortality in Table 5-4. Social inequalities in mortality increased for each cause of death examined and ranged in absolute terms from 0.34 for cancers to 2.18 for respiratory disease. In relative terms, increases in the mortality gap ranged from 1.22 for cancers to 2.01 for heart disease. Note that the pattern of inequalities varied between the measurement of absolute and relative inequalities. In absolute terms, the gap had widened least for cancers, and subsequently increased for accidents, stroke, all causes, suicides, heart disease, all other causes, and respiratory disease. Cancers continued to have the smallest relative increase in inequalities, while stroke, accidents, suicides, all causes, all other causes, respiratory disease and heart disease demonstrated increasingly worse health inequalities over time. Although the narrowest premature mortality gap was reported for all cancers, more substantial inequalities may be found for many specific cancers. For example, using data from the Longitudinal Study for England and Wales, Boyle *et al.* (2004b) demonstrated that the gap had widened more for lung cancer than for other causes of death.

The widening mortality gap resulting from heart disease across all ages was accentuated when premature mortality was studied. Table 5-4 illustrated that the mortality differential increased in absolute terms by 1.87 from 1.85 to 3.72, while the ratio change doubled (2.01). Further investigation of the social gradient for premature heart disease (Figure 5-2) revealed that between 1981 and 2001 the SMRs for quintile 1 reduced from 69.31 to 48.00, while the SMR in the most deprived quintile rose from 128.21 to 178.43.

Shaw *et al.* (1999) aggregated British parliamentary constituencies into deciles and demonstrated a widening mortality gap for premature coronary heart disease. Between 1981-85, premature heart disease was 1.89 times higher for decile 1 (most deprived) than for decile 10 (least deprived), which is similar to the inequalities of 1.85 reported for heart disease in 1981 (Table 5-4). For the 1991-95 period Shaw *et* *al.* (1999) showed that the mortality differential was 2.35 times higher for decile 1, which indicated a relative increase in mortality of 1.24. Therefore, Table 5-4 indicates that premature heart disease has continued to worsen over the past decade. However, caution should be taken in this interpretation, as the two data sets are not directly comparable.

The inequalities in premature suicides did not widen the most between 1981 and 2001 although the increase was substantial. Figure 5-2 demonstrated a reduction in suicides for quintiles 1, 2 and 3 in 2001, and increases for quintiles 4 and 5. Moreover, in 2001, the SMR for quintile 1 was 9.98 percent less than its corresponding SMR in 1981, which contrasted with the 30.33 percent growth demonstrated by quintile 5 in 2001.

Cause Of Death	*Quintile 1: Quintile 5 1981*	*Quintile 1: Quintile 5 2001*	*Absolute Change*	*Ratio Change*
All Cause	1.86	2.99	1.13	1.61
Stroke	1.87	2.77	0.90	1.48
Accidents	1.55	2.32	0.78	1.50
Heart Disease	1.85	3.72	1.87	2.01
Cancers	1.58	1.92	0.34	1.22
Respiratory	3.15	5.33	2.18	1.69
Suicides	2.19	3.42	1.23	1.56
All Others	2.09	4.04	1.95	1.94

Table 5-4 All cause and cause-specific changing ratios between the SMRs for all premature deaths in the least and most deprived quintiles in 1981 and 2001.

5.4.3. Male Mortality – All Deaths

The changing inequalities found for male mortality are provided in Table 5-5, which indicates that absolute inequalities widened by 0.37 for male all cause mortality, 0.25 greater than the absolute change reported for all cause mortality across the total population in Table 5-3. In addition, Table 5-5 shows that the mortality gap increased 24 percent in relative terms for all cause mortality, as shown by the ratio change of 1.24.

As for the total population, heart disease demonstrated the largest absolute and relative increases for males. In absolute terms, the mortality differential for heart disease mortality rose from 1.33 in 1981 to 1.94 in 2001, an increase of 0.61. Figure 5-3 showed that in 2001, heart disease decreased for quintiles 1, 2 and 3, while quintiles 4 and 5 increased significantly. Table 5-5 also highlighted a ratio change in heart disease of 1.46, indicating that the health gap widened more for males than for the total population.

Stroke mortality exhibited the narrowest mortality gap between 1981 and 2001 for males. In addition, stroke was the only cause of death that showed an improvement over time for males. There was an absolute reduction in inequalities of 0.03 between 1981 and 2001. Similarly, the ratio change (0.98) indicated a small improvement in health inequalities. However, the improvements were marginal in comparison to the reductions reported for the total population in Table 5-3.

Cause Of Death	*Quintile 1: Quintile 5 1981*	*Quintile 1: Quintile 5 2001*	*Absolute Change*	*Ratio Change*
All Cause	1.51	1.88	0.37	1.24
Stroke	1.35	1.32	-0.03	0.98
Accidents	1.48	1.89	0.41	1.28
Heart Disease	1.33	1.94	0.61	1.46
Cancers	1.58	1.74	0.16	1.10
Respiratory	2.02	2.06	0.04	1.02
Suicides	2.23	2.74	0.51	1.23
All Other Causes	1.51	2.09	0.58	1.38

Table 5-5 All cause and cause-specific changing ratios between the SMRs for all male deaths in the least and most deprived quintiles in 1981 and 2001.

While inequalities in suicide mortality increased over time, the increase was not as large for males as for the total population. There was an absolute change of 0.51 in suicides for males, which was 0.28 less than the widening gap experienced for the total population. Similarly, the male ratio change for suicides (1.23) was 16 percent lower for the total population (1.39). Table 5-5 also demonstrated a considerable increase in the mortality gap for male accidents. While accidents across the total population experienced a relatively modest rise of 0.15 in absolute terms, accidents for males demonstrated an absolute increase of 0.41 over two the decades. The ratio change for accidents was the second highest specific cause of death examined (excluding the all other causes group). Thus, despite having one of the best mortality rates for (motor) accidents in the European Union (Leon *et al.* 2003*)* the inequalities in male accident mortality widened.

5.4.4. Male Premature Mortality

Similar differences observed between the mortality gap reported for the total population and male population can be identified for premature mortality. First, for all cause premature mortality, the mortality gap for males increased in absolute terms by 1.33 between 1981 and 2001, from 1.87 to 3.19 (Table 5-6). Moreover, the ratio change observed for male premature mortality (1.71) was 0.10 higher than for premature mortality for both sexes combined (Table 5-4). Second, none of the causes experienced a decreasing mortality ratio between 1981 and 2001; however, for male premature mortality, the absolute change in inequalities was smaller than for the total population for stroke, accidents, heart disease, cancers, suicides, and all other causes. Third, as seen for all premature deaths, cancers demonstrated the smallest growth in inequalities. Furthermore, despite the premature inequality ratios being higher for male cancers than all premature cancers (Table 5-4) for both time periods, the relative change was the same (1.22).

While the cancer mortality differentials for each time period were higher for males than all premature deaths, the inequality ratios for heart disease were lower for males. In 1981, the mortality differential was 1.68, compared with 1.85 for all premature heart disease mortality. By 2001, the inequalities had widened to 3.37 for males and 3.72 for all heart disease mortality. Consequently, while the absolute change for males (1.68) was less than the absolute change for the total population premature mortality (1.87), the ratio change was 2.00 for males, and 2.01 for the total population.

Cause Of Death	*Quintile 1: Quintile 5 1981*	*Quintile 1: Quintile 5 2001*	*Absolute Change*	*Ratio Change*
Total	1.87	3.19	1.33	1.71
Stroke	1.78	2.42	0.64	1.36
Accidents	1.55	2.27	0.73	1.47
Heart Disease	1.68	3.37	1.68	2.00
Cancers	1.79	2.17	0.39	1.22
Respiratory	3.14	5.46	2.32	1.74
Suicides	2.40	3.13	0.73	1.30
All Other Causes	2.11	4.51	2.40	2.14

Table 5-6 All cause and cause-specific changing ratios between the SMRs for premature male deaths in the least and most deprived quintiles in 1981 and 2001.

By 2001, the relative mortality gap had widened the most for the all other causes category, whereby mortality inequalities increased considerably from 2.11 to 4.51, demonstrated by an absolute change of 2.40 and a ratio change of 2.14. Given the reductions in most of the specific causes of death being examined, one might expect the percentage of deaths in the 'all other causes' category to also decrease. However, the proportion of deaths in this category rose from 18.64 percent in 1981 to 29.68 percent in 2001 for males under 65 years. However, it appears that while the main causes of death, such as stroke, cancer and heart disease, have been reducing over time, other causes of death, not examined here, may have increased during the same period. For example, the General Register Office for Scotland (2003a) report indicated that the number of drug related deaths had risen from 244 in 1996 to 382 in 2002. The report indicated that the between 29 percent and 37 percent of all drug related deaths per annum were located in the Greater Glasgow health board. In addition, those health boards that contained towns or cities with large populations (for example Lothian, Grampian, and Tayside) also reported a much higher proportion of drug related deaths than predominantly rural health boards.

Recently, there have been a number of reports of the rate of male suicides increasing (McLoone 1996; Christie 2001; Gunnell *et al.* 2003; McLoone 2003). Indeed, between 1981 and 2001, the absolute number of premature suicides increased from 1,554 to 2,242, of which 1,142 and 1,700 were by males. Although the mortality gap widened from 2.40 in 1981 to 3.13 in 2001, male suicides did not exhibit the worst mortality changes over time. Rather, in absolute terms, the suicides mortality gap (0.73) was the third smallest increase over time (equal with accidents, following cancers and stroke). The premature suicide mortality gap widened by 1.30 in relative terms, which was the second smallest increase over time, behind cancers.

5.4.5. All Female Mortality

While the mortality gap widened for all health outcomes except stroke for males (Table 5-5), the equivalent analyses for females (Table 5-7) were more favourable. For example, the all cause mortality ratio between quintile 1 and quintile 5 reduced from 1.41 in 1981 to 1.36 in 2001, resulting in a ratio change of 0.96. Furthermore, there were only three causes of death that exhibited widening inequalities for females: heart disease, cancers, and suicides.

Of these causes, suicides demonstrated the greatest increase the mortality gap. In 1981, there were 1.73 times more female suicides in quintile 5 than quintile 1, but by 2001, the proportion of women committing suicides was over three times higher in quintile 5 at 3.06. Figure 5-5 provides a summary of how the suicide gap made an absolute change of 1.33. By 2001, the SMRs for quintile 1 and 2 had reduced to 59.46 and 63.57 respectively, (compared with 77.09 and 95.83 in 1981). The SMR for quintile 3 made a marginal decrease from 98.23 to 93.33, while quintile 4 increased slightly to 101.94. However, the most dramatic increase was seen by quintile 5 which grew from 133.19 to 181.92. The reduction in quintile 1 with a corresponding increase in quintile 5 produced a ratio change of 1.77.

Cause Of Death	*Quintile 1: Quintile 5 1981*	*Quintile 1: Quintile 5 2001*	*Absolute Change*	*Ratio Change*
All Cause	1.41	1.36	-0.06	0.96
Stroke	1.27	1.04	-0.23	0.82
Accidents	1.18	1.15	-0.03	0.98
Heart Disease	1.47	1.60	0.13	1.09
Cancers	1.32	1.46	0.14	1.11
Respiratory	1.73	1.48	-0.26	0.85
Suicides	1.73	3.06	1.33	1.77
All Other Causes	1.43	1.22	-0.21	0.85

Table 5-7 All cause and cause-specific changing ratios between the SMRs for all female deaths in the least and most deprived quintiles in 1981 and 2001.

In contrast to the slight widening gap (0.04) for respiratory disease exhibited by males, this was the cause that made the biggest absolute improvement between 1981 and 2001 for females. In 1981, respiratory disease mortality in quintile 5 was 1.73 times greater than mortality in quintile 1, which was the same degree of inequalities experienced by suicides for the same period. By 2001, there was a 0.26 reduction in the inequality ratio (1.48) and translated to a ratio change of 0.85, which indicated that respiratory disease mortality had reduced by 15 percent over time. However, the best relative improvement in the social gradient was observed for stroke mortality, which reduced by 18 percent from 1.27 in 1981 to 1.04 in 2001, as indicated by a ratio change of 0.82 in Table 5-7.

5.4.6. Female Premature Mortality

The premature mortality gap for all cause mortality was lower for females than for males, and for all persons. However, Table 5-8 shows that the mortality differential increased by 0.83 in absolute terms from 1.85 in 1981 to 2.68 in 2001. The ratio change for all cause mortality (1.45) also demonstrated that the relative mortality gap widened by 45%, which was considerably less than the widening gap experienced for males (1.71) and all persons (1.61), but still indicates considerably wide inequalities.

There were 542 female premature suicides between 1999-2001 – 76 fewer than between 1980-1982. However, suicides demonstrated the widest relative inequalities in premature female mortality. Table 5-8 showed that suicide inequalities widened from 1.84 in 1981 to 4.48 in 2001. The widening gap in the social gradient for female suicides was apparent in Figure 5-6, in which the SMR for quintile 1 decreased by approximately 29%, while the SMR for quintile 5 was 64% higher in 2001 than in 1981. Although the absolute change of 2.63 in suicide inequalities was not the largest absolute change demonstrated for females, the ratio change (2.43) for premature female suicides represented the largest relative inequalities reported in all of the premature death analyses.

Cause of Death	*Quintile 1:Quintile 5 1981*	*Quintile 1:Quintile 5 2001*	*Absolute Change*	*Ratio Change*
Total	1.85	2.68	0.83	1.45
Stroke	1.96	3.25	1.30	1.66
Accidents	1.55	2.49	0.94	1.61
Heart	2.48	5.22	2.73	2.10
Cancers	1.38	1.68	0.30	1.22
Respiratory	3.17	5.17	1.99	1.63
Suicides	1.84	4.48	2.63	2.43
All Others	2.06	3.33	1.27	1.62

Table 5-8 All cause and cause-specific changing ratios between the SMRs for premature female deaths in the least and most deprived quintiles in 1981 and 2001.

Heart disease demonstrated the largest absolute change in female premature mortality inequalities (2.73). In 1981, the mortality differential was 2.48, which was the second widest mortality gap after respiratory disease. By 2001, heart disease mortality was 5.22 times worse in quintile 5 than quintile 1, overtaking respiratory disease as the most polarised cause of death studied for female premature mortality. The large increase in the mortality gap for heart disease was shown in Figure 5-6, where the SMR for quintile 1 in 2001 (38.08) was significantly smaller than the SMR reported for quintile 5 (198.77).

The smallest absolute change in the premature mortality gap for females was reported for cancers, where the mortality gap demonstrated an absolute increase of

0.30, from 1.38 in 1981 to 1.68 in 2001. Nevertheless, the ratio change for cancers did identify that despite the marginal absolute change, the gap between the least and most deprived quintiles increased by 22 percent. Furthermore, the ratio change reported for cancers was the same for all persons, males and females (1.22). The relative inequalities found in heart disease were also similar for the three population groups examined, although the ratio change for heart disease widened most for females (2.10).

5.5. The Widening Gap II: Consistent Quintiles

The message from the results in the previous section was clear: that with few exceptions, the mortality gap between the least deprived and the most deprived widened during the 20 year period. However, one of the problems with the analysis presented in Section 5.4, (and many other studies) was that the quintiles were not directly comparable. The data for 1981 were based on the population-weighted quintiles derived from the 1981 Carstairs index of deprivation, while the 2001 data were based on population-weighted quintiles derived from the 2001 Carstairs index. Therefore, some of the CATTs attributed to a particular quintile in 1981 will not have been located in the corresponding quintile for 2001. For this reason, the analyses in the previous section can be regarded as 'social' rather than 'geographical' changes in the characteristics of the widening mortality gap in Scotland.

A second problem associated with the results in Section 5.4 is that the mortality data for 1981 were standardised to the population structure in 1981, while the 2001 mortality data were standardised to the 2001 population structure. Therefore, the trend in mortality inequalities presented in the preceding Section should be taken with caution. For the data from 1981 and 2001 to be comparable, two modifications to the previous analyses were required – the population and deprivation quintiles used needed to be standardised. First, the 2001 population weighted deprivation quintiles were applied to the 1981 and 2001 mortality and population data. This ensured the same CATTs belonged to the same deprivation quintile for each time period, and comparisons were made based on the relative deprivation the CATTs in 2001. Second, the 1981 death rates were applied to the 2001 population data to calculate the expected number of deaths in each age and sex group, to allow for direct comparisons between the SMRs over time. Because the 1981 population structure was used as the standard, the SMRs for 1981 averaged 100, and since the number of deaths per annum decreased over the study period, the SMRs for the 2001 period were expected to be considerably less than 100. However, while the 2001 SMRs for the total population would be expected to be less than 100, if mortality had worsened over time for a particular quintile, then the 2001 SMRs for these quintiles would be greater than 100.

There are a number of alternative ways in which the data from 1981 and 2001 could have been standardised. For example, the European Standard population could have been applied to both time periods, and the 1981 population weighted quintiles could have been as the consistent deprivation quintiles. However, the 1981 population was chosen as the standard to identify the relative improvement (or worsening) of mortality over time. Similarly, the 2001 population weighted quintiles were chosen as the standard deprivation index because the CATTs were designed to correspond with the geography of the 2001 census. In addition, it was thought that readers and/or users of the CATTs would wish to make comparisons with the geography of the 2001 census, as these data are more readily available than the 1981 census data.

5.5.1. Total Mortality

Table 5-9 demonstrates the widening mortality gap between 1981 and 2001, using the 2001 population weighted deprivation quintiles and the 1981-based SMRs for 2001, known hereafter as 2001_{81}. The mortality differentials observed for 1981 using the 2001 population weighted quintiles were similar to the mortality differentials provided in Table 5-3, which used deprivation quintiles from 1981. Heart disease was the only cause that demonstrated a wider mortality gap in 1981 when the 2001 quintiles were used, although the increase was marginal (0.02), from 1.39 in Table 5-3 to 1.41 in Table 5-9. The biggest change between the mortality differentials for 1981 was observed for suicides, whereby the mortality gap reduced from 2.03 using 1981 deprivation quintiles to 1.86 when the 2001 quintiles were used. The respiratory disease mortality gap also improved using the 2001 quintiles, from 1.87 to 1.80. The remaining causes of death were between 0.01 and 0.04 lower for the 2001 population weighted deprivation quintiles. Reductions in the mortality gap for 1981 resulted from the redistribution of the population and mortality counts when the 2001 quintiles were applied to the 1981 data.

When the 1981 death rates were applied to the 2001 mortality data to create the 2001_{81} SMRs, the mortality differentials between quintile 1 and quintile 5 were remarkably similar to the differentials observed in Table 5-3, where the 2001 standard population was used. Indeed, the inequalities for all cause mortality (1.58), all cancers (1.60) and the all other causes category (1.55) were the same for both methods. For stroke, accidents, and heart disease, the mortality differential was marginally (0.01-0.02) smaller for the 2001_{81} analyses. Respiratory disease inequalities were 0.02 greater using the 2001_{81} SMRs, and the biggest difference was found for suicides, where the mortality gap in 2001 widened from 2.82 using the 2001 standard population to 3.00 using the 2001_{81} standard. Thus, while the SMRs changed using this method, the widening mortality gap was only marginally affected.

Table 5-9 shows that stroke mortality experienced the best absolute change between 1981 and 2001, during which time the mortality reduced by 0.18. The only other cause of death to experience a decreasing mortality gap was respiratory disease, for which inequalities improved by 0.08 over the period. In contrast, the largest absolute change in the mortality gap was found for suicides, which increased by 1.14. The remaining causes of death all experienced comparatively small absolute changes in inequalities, ranging from 0.09 for the all other causes group, to 0.34 for heart disease.

Stroke mortality also demonstrated a narrowing of the mortality gap in relative terms, with the inequalities ratio 14 percent lower in 2001 than in 1981 (Table 5-9). Similarly, respiratory disease also experienced a reduction in the mortality gap, with a ratio change of 0.96. Relative inequalities in suicide mortality widened the most over time, increasing from 1.86 in 1981 to 3.00 in 2001, and resulting in a ratio change of 1.62. The remaining causes of death all demonstrated increasing inequalities, however the ratio change ranged from 1.06 for the all other causes category to 1.24 for heart disease.

Cause of Death	*1981 Ratio*	*2001_{81} Ratio*	*Absolute Change*	*Ratio Change*
Total	1.44	1.58	0.14	1.10
Stroke	1.29	1.11	-0.18	0.86
Accidents	1.31	1.48	0.17	1.13
Heart Disease	1.41	1.75	0.34	1.24
Cancers	1.41	1.60	0.19	1.13
Respiratory	1.80	1.72	-0.08	0.96
Suicides	1.86	3.00	1.14	1.62
All Other	1.45	1.55	0.09	1.06

Table 5-9 Relative and Absolute changes in all cause and cause-specific SMRs for all deaths in the least and most deprived quintiles in 1981 and 2001, based on 2001 quintiles and 1981 death rates.

A comparison of the inequalities reported using the period specific quintiles (Table 5-3) and the consistent quintiles (Table 5-9) indicates that the two approaches produce very similar conclusions. In terms of absolute change, the all other causes category demonstrated the same level of inequalities (0.09) for both approaches. For all cause mortality and accidents the consistent quintiles were 0.02 higher, while the absolute change was less in Table 5-9 than Table 5-3 for respiratory disease and heart disease. However, the most substantial difference between the conventional 2001 analyses and the 2001_{81} SMRs was reported for suicides, whereby the mortality differential increased by 62 percent between 1981 and 2001. This contrasted with a widening relative suicide gap of 1.39 reported in Table 5-3 where the SMRs using 1981 and 2001 quintiles were analysed.

Thus, Table 5-9 suggests that regardless of whether the data were standardised to a common population and deprivation structure, the gap in mortality for all persons across all ages did not change substantially. Moreover, the same message that could be derived from Table 5-3 was found for the data in Table 5-9: that between 1981 and 2001, the mortality gap narrowed the most for stroke mortality, while the widest mortality gap was exhibited by suicides. In addition, respiratory disease was the only other cause of death that demonstrated a reduction in the mortality gap.

When the causes of death were ranked by either absolute or ratio change, there was a remarkable similarity between the period specific quintiles (Table 5-3) and the consistent quintiles (Table 5-9). In the period specific analyses, stroke mortality demonstrated the best improvement, and was followed by respiratory disease, all other causes, all cause mortality, cancers, accidents, heart disease and suicides. The only difference found for the consistent quintile approach was that cancer inequalities had widened more than for accidents.

5.5.2. Total Premature Mortality

The analysis of premature mortality in Section 5.4 demonstrated that there were substantial differences in the widening mortality gap between all-age and premature mortality. Consequently, the analysis for premature mortality was repeated for the standardised population and deprivation index. Table 5-10 lists the social gradient between quintile 1 and quintile 5 for 1981 and 2001, and also demonstrates the absolute and relative changes in the premature mortality gap over time. When the 2001 population weighted quintiles were applied to the 1981 population and mortality data, the ratio between the least and most deprived quintiles were higher for stroke and respiratory disease compared with the mortality gaps reported by using the 1981 deprivation quintiles (Table 5-4). For stroke mortality, the inequalities widened from 1.87 to 2.04. Similarly, the inequalities reported for respiratory disease increased by 19% from 3.15 to 3.34 when the 2001 quintiles were used (Table 5-10).

Cause of Death	*1981 Ratio*	*2001$_{81}$ Ratio*	*Absolute Change*	*Ratio Change*
Total	1.81	3.01	1.20	1.66
Stroke	2.04	2.76	0.72	1.35
Accidents	1.45	2.32	0.87	1.60
Heart Disease	1.84	3.74	1.90	2.04
Cancers	1.50	1.93	0.43	1.29
Respiratory Disease	3.34	5.31	1.97	1.59
Suicides	1.94	3.68	1.74	1.90
All Other	2.02	3.94	1.92	1.95

Table 5-10 Relative and Absolute changes in all cause and cause-specific SMRs for all premature deaths in the least and most deprived quintiles in 1981 and 2001, based on 2001 quintiles and 1981 death rates

In contrast, the mortality ratios for the remaining causes of death examined were lower when deprivation was standardised. In addition, while the majority of the causes examined were marginally lower for all age mortality when deprivation was standardised (Table 5-9), the reductions for premature mortality were more substantial. For example, the mortality differential for 1981 in Table 5-10 ranged from one percent lower for heart disease to 25 percent lower for suicides. Nevertheless, the inequalities remained substantial in 1981, in which the smallest differential between quintile 1 and quintile 5 was 1.45 for premature deaths due to accidents.

The inequality ratios derived from the 2001$_{81}$ SMRs were similar to those reported for the ratios for 2001 shown in Table 5-4, with marginal increases or decreases for most causes of death. However considerable differences between Table 5-10 and Table 5-4 were found for suicides, which increased by 0.26 when the 1981 death rates were used, from 3.42 using period specific quintiles to 3.68 for consistent quintiles. The mortality differential was 0.01 lower for the all other causes category in Table 5-10.

Since there were notable differences in the mortality differentials between Table 5-10 and Table 5-4, differences in the absolute and ratio change values were also apparent. Table 5-10 demonstrates that the absolute change in the mortality gap over time ranged from 0.43 for cancers to 1.97 for respiratory disease. This contrasted with the period specific quintiles, for which the absolute changes ranged from 0.34 for cancers to 2.18 for respiratory disease. The absolute changes reported in Table 5-10 varied from being 0.21 lower than the absolute change in Table 5-4 (for respiratory disease) to being 0.51 higher for suicides in Table 5-10.

Variations between the ratio changes for the period-specific and consistent deprivation approaches were also evident. Table 5-10 shows that the mortality differentials widened for all eight groups of death studied. Cancers demonstrated the smallest ratio change, with a 29 percent increase over time, while the mortality gap increased the most for heart disease, which more than doubled (in relative terms) over twenty years. The observation that cancers had widened least and heart disease had widened most was consistent with the period-specific ratio change (Table 5-4), although the actual ratio changes were higher in Table 5-10.

The ratio change was 10 percent lower for respiratory disease and 13 percent lower for stroke when the consistent quintiles were used. On the other hand, Table 5-10 showed higher ratio changes for cancers, accidents and suicides. Of these causes, suicides, with a ratio change of 1.90, demonstrated the biggest difference (28%) between the period-specific and consistent deprivation quintiles.

5.5.3. Gender Inequalities

The consistent quintiles were applied to the data for male and females, and analyses were repeated for all deaths and premature mortality. In most cases, the differences between the mortality gaps observed for 1981 and/or 2001 and those based on period specific quintiles (Section 5.4) were marginal (±10%). Therefore, the gender specific results based on the consistent quintiles are not discussed in detail here.

While the majority of differences between the period specific and consistent quintile approaches were marginal, there were some larger differences of interest. For example, in 1981, the female respiratory disease differentials (across all ages) was 1.63 using the consistent quintiles analyses, compared with 1.73 when the period specific quintiles were used (Table 5-7). In contrast, the 1981 female premature mortality differential for respiratory disease was 3.40 when the consistent quintiles were used. This was considerably larger than the differential of 3.17 when the period specific quintiles were used (Table 5-8). The male premature mortality gap for respiratory disease based on the consistent quintiles was also notably different to the results reported for the period specific analyses (Table 5-10). Whereas the premature respiratory disease gap was smaller for females using the consistent quintiles, the gap for males was much higher, at 3.30 compared with 3.14 using period specific quintiles.

While considerable differences were reported for respiratory disease in 1981, suicides demonstrated notable differences for males and females in 1981 and 2001, and for all age and premature mortality. For example, the male suicide mortality gap reported for 1981 reduced from 2.23 for the period specific quintiles to 2.05 when the consistent quintiles were used. By contrast, the mortality gap for 2001 was 2.74 using the period specific quintiles, and increased to 2.91 for the consistent quintiles. Thus, the consistent quintiles identified an absolute increase in suicide inequalities of 0.86, while also indicating a relative increase of 1.42 in suicide inequalities for males. For females, there was an absolute increase in suicide inequalities of 1.73, and a relative increase of 2.09. Furthermore, suicides demonstrated an even greater polarisation for premature mortality, with a relative increase in the gap of 1.57 for males and 3.03 for females.

5.5.4. Comparison of Period Specific and Consistent Quintile Inequalities

The causes of death that demonstrated the smallest and largest ratio changes in inequalities, by the period specific and consistent quintile approaches have been reported in Table 5-11. For all deaths, both approaches identified a relative reduction in inequalities for stroke mortality. Furthermore, the ratios reported for stroke by the consistent quintiles approach were within 2 percent of the ratios found by the period specific quintile approach.

The largest ratios reported by both techniques were identical for females and all persons, which indicated that suicide inequalities had increased most over time. For males however, the period-specific approach suggested that heart disease inequalities had widened the most, while suicides exhibited the widest mortality gap for the consistent quintiles. Furthermore, the consistent quintiles approach reported much wider ratio changes than for the period specific quintiles.

		All Deaths			*Under 65 Deaths*		
		Male	*Female*	*Total*	*Male*	*Female*	*Total*
Period Specific	Smallest Ratio Change	Stroke (0.98)	Stroke (0.80)	Stroke (0.87)	Cancers (1.22)	Cancers (1.22)	Cancers (1.22)
	Highest Ratio Change	Heart (1.46)	Suicides (1.77)	Suicides (1.39)	Heart (2.00)	Suicides (2.43)	Heart (1.22)
Consistent	Smallest Ratio Change	Stroke (0.96)	Stroke (0.80)	Stroke (0.86)	Stroke (1.16)	Cancers (1.26)	Cancers (1.29)
	Highest Ratio Change	Suicides (1.42)[1]	Suicides (2.09)	Suicides (1.62)	Heart (2.04)	Suicides (3.03)	Heart (2.04)

Table 5-11 The best and worst ratio changes in the widening mortality gap, by method of classification

The smallest ratio change for premature mortality was demonstrated by cancer mortality for males, females and all persons in the period-specific analysis. In contrast, inequalities in stroke mortality widened the least for males when the consistent quintiles were used, while the mortality gap for cancers increased the least for females and all persons. Moreover, the ratio changes for cancers were marginally higher for the consistent quintiles than for the period specific approach. The largest increases in the relative premature mortality gap were shared between heart disease and suicides for both period specific and consistent quintiles.

Once again, the consistent quintiles demonstrated the wider increases over time, but the difference between the ratio changes reported for the period specific and consistent quintiles were considerably greater for the premature deaths than those differences reported for all deaths. For example, whereas the ratio change for suicides was 32% higher for the consistent quintiles than period specific quintiles for all age mortality, the ratio change reported for female premature suicides was 60% higher than the period specific quintiles for premature female mortality.

Since 1981, there has been an overall improvement in the quality of life. More people have access to vehicles, for example, and the quality of housing has also

[1] All Other Deaths excluded from the construction of this table.

generally improved. Thus, the characteristics of the CATTs that were categorised into quintiles based on the 2001 deprivation index were potentially very different to the CATTs allocated to the corresponding quintiles in 1981. Therefore, if the quintiles derived from the 1981 deprivation index were used in the standardisation process, different mortality gradients to those presented in this section might have been produced. Nevertheless, regardless of which deprivation index should be used, this section has emphasized that when comparable zones were compared, the mortality gap has apparently widened more than had been reported using the conventional, period specific, deprivation quintiles.

5.6. The Widening Mortality Gap III: Mobility of CATTs

While the consistent quintiles presented in Section 5.5 ensured that the same CATTs were allocated into the same quintile in 1981 and 2001, the method did not account for the overall relative improvements to the quality of social conditions between 1981 and 2001. A CATT in quintile 5 (for example) in 1981 may have improved over time and belonged to a different quintile in 2001. Thus, while the approach in Section 5.5 ensured that the same CATTs could be compared to determine the widening gap, the method did not account for the upward or downward relative social mobility that places might have experienced.

Social mobility typically refers to the movement up or down the social class hierarchy, and can be analysed in of two ways. Intra-generational social mobility refers to the migration through the hierarchy during an individual's working life. Alternatively, inter-generational social mobility refers to the parental social class location and the social class status of an individual after leaving parental care. Power *et al.* (1996) used the 1958 birth cohort, a longitudinal study based in the UK, to investigate the relationship between social mobility and self reported health status. They used self-reported health status at ages 23 and 33, and two social position indicators to classify social class origins (father's social class at birth, and father's social class at age 16) and social class destinations (subject's own social class at ages 23 and 33) to explore the relationship between social mobility and health inequalities. They found that individuals who rated themselves as having poor health tended to move down the social class hierarchy, although this did not explain health inequalities at age 33.

Recently, Boyle *et al.* (2004b) used a group of people from the Longitudinal Study (LS) for England and Wales, living in non-deprived households and who did not move between 1971 and 1991, to determine whether changes to the relative deprivation of their neighbourhood over time influenced their health and mortality experiences. They used the Carstairs index of deprivation for 1971 and 1991 to identify a profile of changing relative deprivation. For example, a ward might have belonged to quintile 1 in 1971 and remained in quintile 1 in 1991. Alternatively, another ward belonging to quintile 1 in 1971 might have worsened (relatively) over time and, as a result, was allocated to another quintile in 1991. Boyle *et al.* (2004b) showed that members of the LS sample that lived in wards that were in quintile 1 in 1971 and 1991 had significantly better health (in terms of morbidity and mortality) than participants that lived in wards that were in quintile 5 in 1971 and 1991. In addition, participants that lived in wards that improved relatively over time demonstrated better health than those participants that lived in wards whose relative deprivation worsened over time.

It is possible for areas to experience social mobility in the same way that individuals move through the social hierarchy. However, area-based mobility analyses are rare because few studies are based on consistent geographies. Although the population and mortality data used for the current study do not have a longitudinal dimension, the CATTs can be considered comparable as they are geographically consistent. Thus, a similar approach to the technique used by Boyle *et al.* (2004b) could be constructed. In this section, the widening mortality gap is explored based on the changing relative deprivation of the CATTs, for all persons and all premature deaths.

5.6.1. Comparing 1981 and 2001 Quintiles

Throughout this chapter, population weighted quintiles have been used, with around one million residents per deprivation group. While the population is evenly divided, Table 5-12 shows that in 1981, the number of CATTs within each quintile varied considerably. There were 42 fewer people in quintile 5 than quintile 1, and 704 fewer CATT's in the most deprived quintile. Thus there were considerably more areas in the least deprived quintile than in the most deprived quintile in 1981.

1981 Quintile	*Number of CATTs*	*1981 Population*
1	2,425	1,006,790
2	1,962	1,006,798
3	1,923	1,005,390
4	2,026	1,008,172
5	1,721	1,006,748
Total	10,057	5,033,898

Table 5-12 The number of CATTs and total population within each 1981 population weighted quintile.

Similarly, Table 5-13 also shows the number of CATTs within each 2001 population weighted quintile. There were less CATTs in the deprived quintile than in 1981, but there were also fewer CATTs in the most deprived quintile. Furthermore, whereas in 1981 there were fewer people in quintile 5 than quintile 1, in 2001 there were 1,657 more persons in quintile 5 than quintile 1. Table 5-13 also reports the 1981 population distribution, based on the 2001 population weighted quintiles. It can be seen from Table 5-13 that a considerable proportion (27%) of the 1981 population were located in the most deprived quintiles in 2001. In contrast, there only 16 % of the 1981 population were apportioned to the least deprived quintile. Thus, the relative deprivation of the CATTs changed between 1981 and 2001.

2001 Quintiles	*Number of CATTs*	*2001 population*	*1981 Population*
1	2,040	1,010,740	838,810
2	1,550	1,014,144	829,630
3	1,690	1,012,676	933,548
4	2,198	1,011,990	1,074,511
5	2,579	1,012,397	1,357,399
Total	10,057	5,061,947	5,033,898

Table 5-13 The number of CATTs and the 1981 and 2001 populations within each 2001 population weighted quintile

5.6.2. Constructing the Deprivation Index

As Table 5-12 and Table 5-13 have shown, the number of CATTs with each deprivation quintile varied for the 1981 and 2001 censuses. Furthermore, because considerably more people from 1981 were allocated to the most deprived quintile for 2001, it was apparent that some places had changed over time, relative to other places. While the analyses in Section 5.5 were more reliable than those in Section 5.4, using the 2001 deprivation as the consistent geography did not account for social mobility. Thus, for a truly consistent evaluation of the widening gap to be made, the deprivation index needed to be relevant to the entire study period.

In this analysis, the variables used to construct the 1981 and 2001 deprivation indices for CATTs were 'stacked' together. This resulted in a file containing 20,114 observations, with two rows of information for each CATT. One Carstairs deprivation index was then calculated for the complete time period. This single index ranged from –5.22 for the least relatively deprived CATTs to 17.09 in the most deprived CATTs. Next, the index was sorted and population-weighted quintiles were constructed for the 20,114 CATT observations, based on the total combined 1981 and 2001 populations (10,095,845). Each quintile comprised of approximately 2.01 million people, and a combination of 1981 and 2001 CATT observations.

Thus, it was possible to distinguish between those CATTs that remained in the same quintiles, and those CATTs that had improved or worsened over time. Note that while this dataset comprised of quintiles, when the data were divided into 1981 and 2001 files, the classifications could not be referred to as quintiles, since they contained a disproportionate number of CATTs for each period. Therefore, this classification became known as 'social mobility groups'.

Seven social mobility groups were chosen to explore the widening mortality gap, which are shown in Table 5-14. In fact, there were 25 possible social mobility groups. However, as this section is interested in the changes to quintile 1 and quintile 5 over time, many of these combinations were excluded from the analysis. Three groups represented CATTs that belonged to quintiles that did not change over time. A further two groups represented those CATTs whose relative deprivation worsened between 1981 and 2001. Conversely, the final two groups represented CATTs whose relative deprivation improved over time. From these, two particular trends were expected. First, the Q1 1981, Q1 2001 group was expected to have lower mortality than the other two groups whose quintiles did not change over time. Second, those CATTs that improved (for example, Q5 1981, Q1-4 2001) would be expected to have lower mortality rates than those that worsened over time, or compared to Q5 1981, Q5 2001.

Social Mobility Group	*Definition*	*Number of CATTs*
Q1 1981, Q1 2001	Quintile 1 in 1981 Quintile 1 in 2001	1,230
Q2-4 1981, Q1 2001	Quintile 2-4 1981 Quintile 1 in 2001	1,433
Q1 1981, Q2-4 2001	Quintile 1 in 1981 Quintile 2-4 in 2001	111
Q2-4 1981, Q2-4 2001	Quintile 2-4 in 1981 Quintile 2-4 in 2001	3,846
Q5 1981, Q1-4 2001	Quintile 5 in 1981 Quintile 1-4 in 2001	2,789
Q1-4 1981, Q5 2001	Quintile 1-4 in 1981 Quintile 5 in 2001	55
Q5 1981, Q5 2001	Quintile 5 in 1981 Quintile 5 in 2001	593

Table 5-14 Social mobility groups created from the combining the 1981 and 2001 deprivation indices

Table 5-14 also showed that between 1981 and 2001, 42 percent of the CATTs experienced upward social mobility. Of these, two thirds moved from the least deprived to less deprived quintiles. Only 55 CATTs experienced downward mobility to the most deprived quintile in 2001. However, there was a further 111 CATTs that moved from quintile 1 to more deprived quintiles. There were 593 CATTs that were in the most deprived quintiles in 1981 and 2001, less than half the number of CATTs that belonged to the least deprived quintiles for both periods.

5.6.3. All Cause Mortality – All Ages

Standardised mortality ratios were calculated for mortality across all ages and for premature mortality 1981 and 2001, for the seven social mobility groups outlined in Table 5-14. The SMRs for 1981 were calculated using the 1981 death rates, while the 2001 SMRs were calculated using both the 2001 and 1981 expected rates, to determine whether the method of standardisation affected the widening gap results. Figure 5-7 provides the SMRs for all cause mortality by social mobility group, standardised to the 1981 population. Note that standardising by the 1981 population resulted in the 2001 mortality data having lower SMRs than in 1981. This was the same approach used for the 2001 data in 5.5, and reflects the relative improvements in mortality over time.

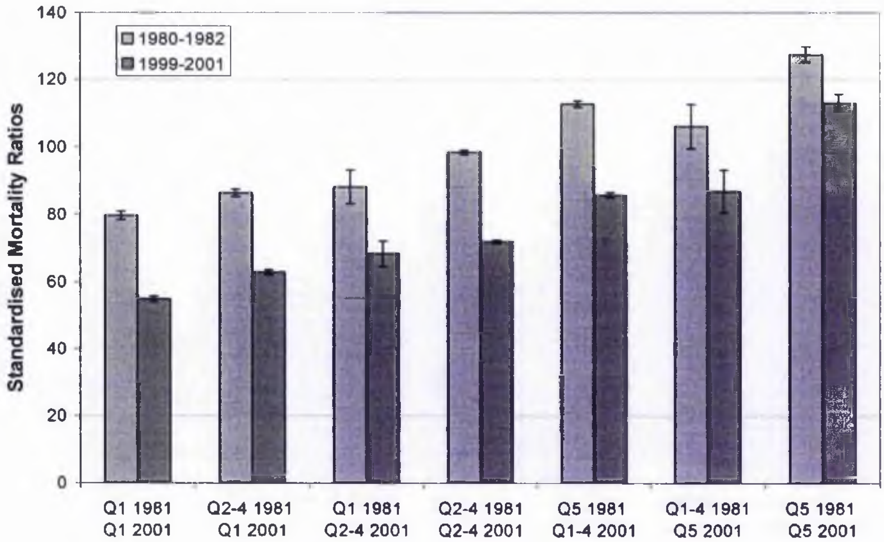

Figure 5-7 All cause mortality (1981 and 2001) by social mobility group

Figure 5-7 shows that the SMRs improved significantly for each social mobility group, however, there were differences in the degree to which improvements were experienced. As expected, those CATTs that were consistently in the least deprived areas had the most favourable mortality experiences, while those CATTs that remained in the most deprived quintiles experienced significantly higher mortality than all other social mobility groups. Similarly, the upward social mobility groups experienced comparably better mortality experiences than those groups which worsened over time.

The relative improvement in mortality over time could also be determined from Figure 5-7. Those CATTs that belonged to quintile 1 for 1981 and 2001 exhibited the biggest relative improvement in which the SMR for 2001 was by 31.07 percent lower than reported for 1981. By contrast, those CATTs that were the most deprived in 1981 and 2001 only demonstrated an improvement of 11.28 percent. The mobility groups that represented upward mobility also had better health in 1981 and 2001. For example, those CATTs that experienced upward mobility from quintile 5 demonstrated an improvement of 23.96 percent between 1981 and 2001, while the CATTs that moved down from the less deprived quintiles to the most deprived quintile improved by just 18.14 percent. Similarly, the CATTs that moved from the middle quintiles (i.e. quintiles 2-4) to quintile 1 also showed a better relative improvement (27.25 percent) than CATTs that moved from quintile 1 down to the middle quintiles (22.54).

In 1981, the mortality in the CATTs that were in the most deprived quintiles in 1981 and 2001 was 1.60 times higher than the mortality for in the CATTs that were consistently in quintile 1. By 2001, the mortality gap had widened to 2.06, an absolute change of 0.46 and a relative widening of 29 percent. It should be noted that this analysis was repeated for the period-specific based analyses, and the results were very similar.

5.6.4. All Cause Mortality – Premature Mortality

When the analyses were repeated for premature mortality (Figure 5-8), the social gradient was much more clear than was observed for all persons mortality, although the 1981 mortality for those CATTs that moved from quintile 1 to the middle quintiles was slightly lower than might have been expected. The clearest difference between Figure 5-7 and Figure 5-8 was the significant increase in mortality in the group of CATTs that were in the worst deprivation quintile in 1981 and 2001 for premature mortality. For the CATTs that remained in quintile 1 for both periods, there was a relative improvement in mortality of 46.28 percent, with the SMR reducing from 65.20 in 1981 to 35.03 in 2001. In contrast, for those CATTs that were persistently in the most deprived quintile, Figure 5-8 demonstrates that mortality worsened over time. The SMR for the Q5 1981, Q5 2001 group was 137.85 in 1981, and increased to 153.98 for 2001, indicating an absolute increase in mortality of 16.13. In relative terms, the mortality increased by 11.70 percent between 1981 and 2001.

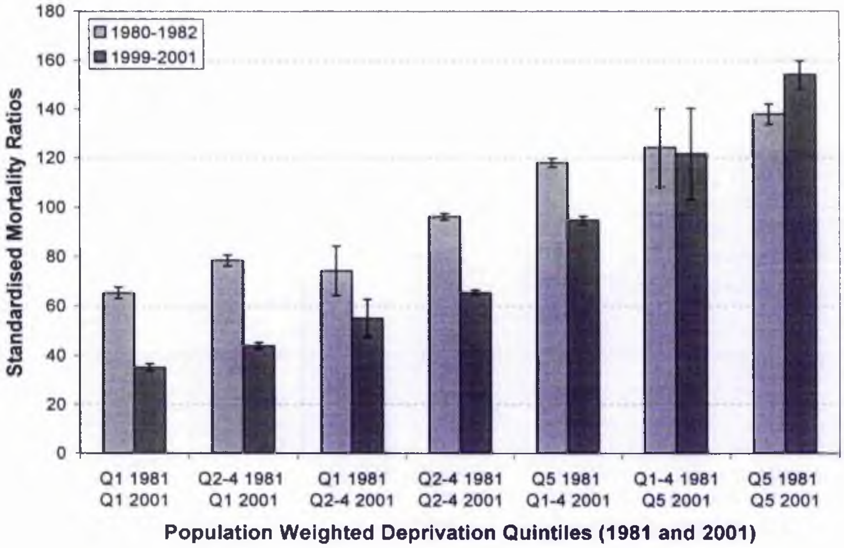

Figure 5-8 All cause premature mortality (1981 and 2001) by social mobility group

In addition, the relative improvements over time were greater for the categories that represented upward social mobility than those CATTs that experienced downward mobility. For example, those CATTs that moved from the middle quintiles to quintile 1 exhibited a relative improvement of 44.19 percent, while those CATTs that moved down from quintile 1 only demonstrated a relative improvement of only 25.93. Similarly, those CATTs that experienced upward mobility from quintile 5 improved by 19.77 percent, while the relative improvement for CATTs that moved into quintile 5 in 2001 was just 2.02 percent. In 1981, the mortality experienced by those CATTs that were in the most deprived quintile over time was 2.11 times higher than the mortality for those CATTs that were in the least deprived quintiles. In 2001, the mortality gap had doubled and was 4.40 times worse in the consistently deprived quintiles.

5.6.5. Summary

This section has demonstrated that the number of CATTs in a particular quintile differed between 1981 and 2001. Moreover, a considerable amount of the 1981 population were apportioned to quintile 5 for the consistent quintiles analysis discussed in Section 5.5. To overcome these problems, a single deprivation index was created for the entire study period. This resulted in the construction of 'social mobility groups' and the subsequent analysis of the mortality characteristics within areas that experienced different types of changes in deprivation over time.

Areas that were consistently located in the least deprived quintile in 1981 and 2001 experienced significantly lower mortality than places that were located in the most deprived quintiles for the same time periods. Moreover, the places that experienced upward social mobility, for example those CATTs that moved from quintile 5 in 1981 to quintiles 1-4 in 2001, also had significantly lower mortality that those places that became worse over time. Nevertheless, a social gradient was still evident, and was more pronounced for premature mortality than for all age mortality. Furthermore, the same mobility groups that demonstrated comparatively better SMRs also showed the best relative improvements in mortality over the study period. This section has therefore highlighted that social mobility is an important condition that should be considered when patterns over time are explored.

5.7. Discussion

This chapter has explored the widening mortality gap in Scotland between 1981 and 2001. Individual mortality data for 1980-1982 ('1981') and 1999-2001 ('2001') were aggregated to CATT2 zones, which were then divided into population-weighted quintiles based on the 2001 Carstairs index of deprivation. Standardised Mortality Ratios (SMRs) were constructed for all cause mortality, accidents, stroke, heart disease, all cancers, respiratory disease and suicides. The SMRs were calculated for males and females, separately and combined, in five-year age bands (0-4, 5-9 ... 85+) for all deaths and all deaths occurring under 65 years old. SMRs for the 1981 mortality data were created using population data derived from the 1981 census. Similarly, the 2001 mortality data were analysed using population data derived from the 2001 census. Additionally, the 1981 death rates were applied to the 2001 mortality data in order to consistently analyse relative changes in mortality over time.

Sections 5.2 and 5.3 demonstrated the extent of the social inequalities apparent in 1981 and 2001 respectively. The analyses for all cause mortality in 1981 showed that the mortality differential was higher for males than for females or for all persons. In addition, the inequalities were notably higher for premature mortality than for differential based on all deaths. For example, quintile 5 (the most deprived) experienced 1.46 times more mortality from all causes and for all ages than quintile 1 (the least deprived), increasing to 1.86 for premature mortality. For all male mortality, the inequalities increased to 1.51, although male premature mortality inequalities were more similar to those reported all premature deaths at 1.87. The inequalities reported for 1981 were similar to those reported for the same period by Carstairs and Morris (1991). For example, they showed that all cause mortality for all ages was 1.34 in the most deprived quintiles, increasing to 1.75 for premature mortality.

Similarly, the cause specific analyses reported in Section 5.2 were comparable to the findings of Carstairs and Morris (1991). For example, using their seven DEPCAT groupings, they reported inequalities for stroke (for the total population and all deaths) to be 1.17, while the quintile analyses here demonstrated a 1.30 mortality gap for stroke. Note that the current analyses were not always higher than Carstairs and Morris' findings. Suicides for example, were reported in Section 5.2 as being 2.03 times greater in the most deprived quintiles while Carstairs and Morris reported inequalities as being 2.52 times greater in the most deprived DEPCAT compared with the least deprived DEPCAT.

Section 5.3 demonstrated that by 2001, the mortality gap had widened considerably, to 1.58 for all deaths and 2.99 for all premature mortality. The inequalities for cause specific mortality were also much higher in 2001 than 1981. For example, the inequality ratio for premature male respiratory disease was 5.46 in 2001, considerably higher than 3.14 reported for 1981. The inequalities reported in Section 5.3 indicated that health inequalities have continued to widen since the mid 1990s. However, caution should be taken, as these data are not directly comparable.

The changes in the mortality gap between 1981 and 2001 were assessed using two approaches. First, period-specific quintiles were used, in which mortality data from 1981 and 2001 were standardised according to the deprivation quintiles and population composition of the respective period. When mortality across all ages was examined, inequalities reduced for some causes of death (e.g. stroke and respiratory disease), particularly among females. However, inequalities widened for each cause of death studied among premature mortality (<65 years), with a relative increase of 1.22 each, premature cancer inequalities widened the least for males and females. However, inequalities in premature suicide among females experienced a relative increase of 2.43, growing from 1.84 in 1981 to 4.48 in 2001. However, these inequalities were not strictly comparable because some CATTs were likely to be located in different deprivation quintiles, and different population structures were used to calculate the SMRs for 1981 and 2001.

In order to make a more reliable comparison, the analyses in Section 5.4 were repeated by applying the 2001 population weighted quintiles to the 1981 data, thus ensuring that the same CATTs were being compared through time. In addition, the 2001 data were standardised to the 1981 death rates, indicating relative increases or reductions in mortality for 2001. The widening gap based on these 'consistent quintiles' were reported in Section 5.5. Although the SMRs for 2001 were generally much lower for the consistent quintiles, the differences between the inequalities exhibited by the period specific quintiles and the consistent quintiles were marginal (±10%) for most causes of death. Moreover, the reductions in relative inequalities found for the period specific quintiles were also shown by the consistent quintiles. However, the consistent quintiles had the most effect on the widening inequalities reported for suicides. For the total population, the gap widened from 1.39 using the period specific quintiles to 1.62 when consistent quintiles were used. Similarly, the premature suicide mortality gap widened from 1.56 from the period specific quintiles to 1.94 with the consistent quintiles.

While the consistent quintiles approach ensured that the same CATTs were being compared over time, the approach did not account for the upward or downward social mobility of CATTs. In the same way that an individual is thought to move up or down the social (class) hierarchy when s/he moves to a relatively better or worse occupation, areas can also move up or down a social (deprivation) hierarchy, as defined by a composite deprivation or poverty measure. Because most studies are not based on consistent areas, it is not normally possible to account for area-based social inequalities.

However, because the analyses in this chapter were based on the CATTs, it was possible to create a composite deprivation index for the entire study period. It was shown that those CATTs that were always located in the most deprived quintile had the worst health and those CATTs that were always in the least deprived quintile had the lowest mortality. Moreover the CATTs that experienced downward social mobility had worse mortality than their upward mobility counterparts.

During the 1980s and 1990s, following the Black Report (Townsend *et al.* 1992) and the Health Divide (Whitehead 1992), there were a number of initiatives established to improve health and health inequalities. The widening gap analyses in Sections 5.4 and 5.5 were consistent with the existing literature, and suggested that the mortality gradient had worsened over time for the majority of causes of death. Furthermore, these findings suggested that despite absolute numbers of deaths decreasing over time (except suicides), and in spite of the health promoting initiatives operating in Scotland, such as Social Inclusion Partnerships, the mortality gaps were continuing to widen over time. In contrast, the fact that those CATTs that had moved from quintile 5 in 1981 to another quintile in 2001, or from quintiles 2-4 in 1981 to quintile 1 in 2001 demonstrated comparatively better health than those CATTs that moved down through the deprivation quintiles suggested that area based measures targeting beneficial health outcomes may have been successful in Scotland.

This chapter confirmed that the mortality gap in Scotland had widened over the past twenty years. Furthermore, the gap in mortality for the entire population is considerably lower than for premature mortality. The smallest gap in mortality across the total population was demonstrated for female cancer mortality, with an inequality ratio of 1.08. These findings support existing literature that examines health inequalities. For example, social gradients have been reported elsewhere for all cause mortality (Phillimore *et al.* 1994; Jessop 1996; Haynes and Gale 1999; Leyland 2004; Shaw *et al.* (2000b); accidents (Williamson *et al.* 2002; Haynes *et al.* 2003); stroke (Huff *et al.* 1999; Maheswaran and Elliott 2003); heart disease (Lovett *et al.* 1986; McLoone and Boddy 1994; Frankel *et al.* 1999; Huff and Gray 2001; Singh and Siahpush 2002a); respiratory disease (Law and Morris 1998; Gemmell *et al.* 2000; Senior *et al.* 2000; Maheswaran *et al.* 2004) and suicides (Gunnell *et al.* 2003; Regidor *et al.* 2003; Middleton *et al.* 2004; Singh and Siahpush 2002b). Suicides demonstrated the most striking changes over time. Suicide was the only cause of death that continued to increase between 1981 and 2001. Furthermore, suicide inequalities were particularly wide in 1981 and continued to over time. Therefore, the widening suicide gap is revisited in more detail in Chapter Seven.

The negative association between population decline and high mortality rates has been known for some time (Lewis-Faning 1930). Recently, the relationship has been examined using contemporary data with particular interest on the impacts the relationship has on the distribution of resources (Davey Smith *et al.* 1998b). They found a strong (r=-0.68) association between population change and mortality, and indicated that this was an example of the healthy migrant effect. Thus, it was posited, that the areas that suffered greatest population decline were also the places where health resources were required the most, as these areas comprised of more people with ill health.

The relationship between population change and mortality has been explored for 292 County Boroughs in Britain (Davey Smith *et al.* 1998b; 2001c), 200 areas within Madrid, (Regidor *et al.* 2002) and 16 municipalities in Finland (Molarius and Janson 2000). However, two areas of interest have not yet being assessed: the role of geographic scale, and the role that socio-economic deprivation has on the population change and mortality relationship. Thus, the next chapter explores these two questions in detail, extending the work reported by Boyle et al (2004a).

6. Population Change, Deprivation and Mortality

6.1. Introduction

This Chapter examines the relationship between population change and mortality. Unlike in previous Chapters, which examined total and premature mortality, this Chapter focuses on premature mortality. In particular, two questions that have not yet been answered in contemporary studies are investigated. The first focuses on the effect that changing the geographic scale of analysis has on the relationship between population change and mortality. For this analysis CATT2s have been aggregated to approximate to four higher geographies: Health Boards, Council Areas, 1991 Districts, and Parliamentary Constituencies. These geographies contain 15, 32, 56, and 73 zones respectively, and broadly represent some of the scales discussed in existing investigations into population change and mortality. Standardised mortality ratios from 1999-2001 and percentage population change between 1981 and 2001 have been calculated for all persons aged below 65 years. Moreover, SMRs have been calculated for total premature mortality, accidents, stroke, heart disease, cancers, respiratory disease, suicides and all other causes of death together. By investigating the association of premature mortality and population change and deprivation, the analysis in this chapter partially replicates the work by Davey Smith *et al.* (1998b, 2001c) and Boyle *et al.* (2004a). Furthermore, it was shown in the previous chapter that inequalities were notably higher for premature mortality than inequalities observed across all age groups. Such inequalities would potentially increase in declining areas if resources allocated based on population fail to provide adequate levels of provisions.

The second question examined here tests the hypothesis that the relationship between population change and mortality may diminish once deprivation circumstances are controlled for. There is a correlation between deprivation and population change and it is possible that the negative relationship between population change and mortality is less important once deprivation is accounted for. Therefore, the CATT2s have been aggregated into three groups based on population change, and SMRs for premature mortality for each category have been produced. Furthermore, the relationship between deprivation and mortality, for each population change category, is also examined.

This Chapter begins by outlining the characteristics of population change in Scotland between 1981 and 2001, which are discussed in terms of the total population, and geographical variations the 32 Council Areas of Scotland for 2001. This is followed by a review of the contemporary literature concerning the relationship between population change and mortality. These two Sections provide the context for the remainder of the Chapter, which examines the association of population change premature mortality (from all causes and for specific causes of death), first in relation to geographic scale and second, with regard to deprivation.

6.2. Population Change in Scotland, 1981-2001

The Scottish population increased steadily during the first three quarters of the 20th Century, with the exception of the period around the Second World War. However, the population has declined since 1970-1975, when the population peaked at an estimated 5,234,700 (GROS 2003b). In the 20 years with which this study is concerned, the total population declined by 2.2%, from 5,180,200 in 1981 to 5,064,200 in 2001.

However, as Figure 6-1 shows, the population did not decrease evenly across Scotland between 1981 and 2001. Rather, the population increased in half of the 32 Council Areas. Aberdeenshire experienced an increase of 20.1%, while the Perth & Kinross, East Renfrewshire, East Lothian and West Lothian Council Areas increased by at least 10.7%. Of the remaining 11 Council Areas whose population increased, 7 rose by at least 1% while the population in four Council Areas increased by less than 1.0%. The surge in the population in Aberdeenshire might be attributable to the growth of the North Sea oil industry, which is based offshore from Aberdeen.

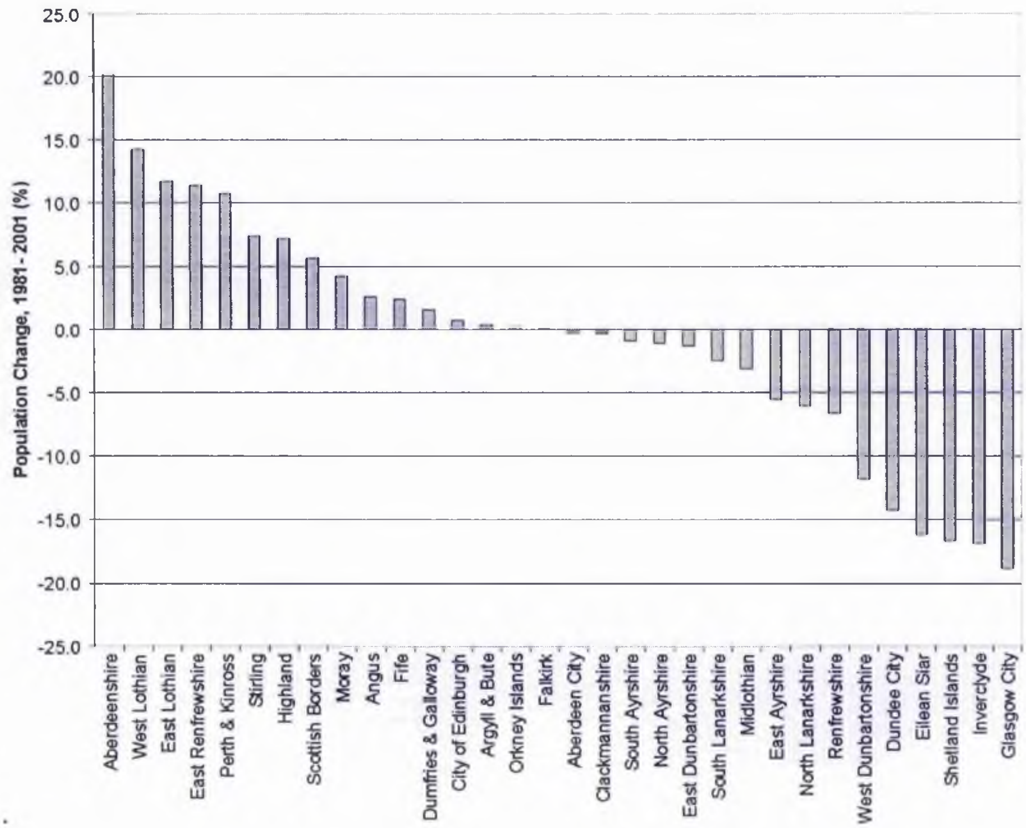

Figure 6-1 Population change (%) between 1981 and 2001, for Council Areas

Figure 6-1 also demonstrates that the Glasgow City Council Area experienced the largest population decline of 18.8%, falling from 712,368 in 1981 to 578,710 in 2001. West Dunbartonshire, Dundee City, Eilean Siar (the Western Islands), Shetland Islands, and Inverclyde each experienced more then 11% population decline. The remaining 10 Council Areas suffered population declines that ranged between –0.3% (Aberdeen City and Clackmannanshire) and –6.6% (Renfrewshire).

Therefore, it can be seen that although the Scottish population declined by 2.2% between 1981 and 2001, declines were not experienced in all of the Council Areas. With this in mind, the remainder of the chapter reviews the contemporary research into the association between population change and mortality, before examining the influence that geographic scale and deprivation have on this relationship in a Scottish context.

6.3. Contemporary Research into the Population Change and Mortality Relationship

Research into the association between mortality and population change has a long history, but there has been renewed interest in this relationship recently. Early studies showed that 'Healthy Districts' in England and Wales (as defined by Farr 1837; 1885) with the highest mortality rates occurred in places that had experienced the most population growth (Lewis-Faning 1930). By contrast, Hoffman (1906) demonstrated that during the same period, the highest mortality occurred in areas across the United States that suffered population decline. More recently however, it has been consistently shown that the areas experiencing population decline have above average mortality.

O'Reilly (1994) examined the relationship between the Townsend deprivation score and mortality for 26 Districts in Northern Ireland. He found that while mortality had improved in all Districts between 1980-82 and 1990-92, the more relatively deprived areas were improving more slowly than the less deprived areas. Furthermore, those Districts that had experienced a net population loss exhibited the smallest improvement. The relationship with mortality and net population loss was found to be 0.667 ($p<0.001$).

Similarly, Davey Smith *et al.*, (1998b) examined the relationship between population change between 1971 and 1991 and mortality between 1990-1992 for 292 county boroughs and urban and rural remainders of counties in Britain. They reported a correlation of –0.62 ($p<0.001$) between population change and mortality for the total population, indicating that mortality was highest in those Parliamentary Constituencies that experienced the greatest population decline. The relationship was stronger for men (-0.68, $p<0.001$) than for women (-0.50). They investigated the significance of social class on the relationship by controlling for the proportion of the population in social classes IV and V, or whose social class was unclassified in 1991. Using partial correlations the relationship was weakened to –0.49, but this still supported the work by O'Reilly (1994).

Molarius and Janson (2000) explored the relationship between population change (1975-1994) and mortality (1992-96) across 16 Swedish municipalities in the county of Värmland. For males, they found a significant negative relationship for all cause mortality ($r= -0.61$, $p =0.013$), cancer ($r= -0.6$, $p=0.011$), alcohol-related deaths ($r= -0.56$, $p=0.025$), and mental disorders ($r= -0.50$, $p=0.050$). By contrast, the relationship for female all cause mortality was positive, although not statistically significant ($r=0.15$, $p=0.57$). Furthermore, diabetes-related mortality was the only cause that exhibited a statistically significant negative relationship ($r= -0.49$, $p=0.055$) for females. They also used partial correlations to control for deprivation, represented by income and education levels, and found that approximately one third of the relationship between population change and all cause mortality was explained by the proportion of high income earners. Although all of the cause specific mortalities were inversely related to population change for males, female mortality was more varied. The authors suggested that the inverse relationship found for males was strengthened by migration, and that this might have been due to less deprived people having greater ability to move to more socially and physically attractive areas (p. 772). On the other hand, they argued that the relationship for females was cause-specific.

Davey Smith *et al.* (2001c) continued the debate by replicating their original analyses (Davey Smith *et al.* 1998b) for a range of different health outcomes. They found that, for the majority of causes, the relationship between population change and mortality was both inverse and significant. In addition, they argued that the analysis by Molarius and Janson (2000) was doubtful due to the small sample size and because there was considerable variation around the estimated correlations.

Regidor *et al.* (2002) classified 200 zones in the region of Madrid by the degree of population change between 1986 and 1996 and found that male mortality between 1996-97 was higher in areas whose population had shrunk than in areas that had grown ($r= -0.76$, $p=0.030$). However, among females, the association was not significant ($r=-0.13$, $p>0.05$). There was no relationship between population change and their indicators of wealth and/or material deprivation, as represented by per capita household income and percentage of unemployment in 1996. However, when the authors examined mortality for 1996-1997 in areas with growing and shrinking populations by socio-economic status, they found that mortality was 0.86 times lower for men in a lower socio-economic class (less deprived) living in areas whose population was growing than males in the same socio-economic group living in areas which experienced population decline. For males in the upper socio-economic group, male mortality was 0.76 times lower in population growth areas than in population decline areas. In contrast, the relationship was only seen in the upper socio-economic group among females, in which mortality among females in population growth areas was 0.87 times lower than for females in areas of population growth. The authors suggested that health inequalities among males in growing and shrinking areas were due to health-selection bias in migration. However, among females the health selection bias was evident among the upper socio-economic group.

Therefore, these contemporary studies all suggest that the inverse relationship between population change and mortality is associated with the selective migration of more affluent people moving out of the most deprived areas to more aesthetic environments. O'Reilly and Stevenson (2003) tested this hypothesis by examining the role that selective migration had on the spatial distribution of health inequalities in Northern Ireland. They used data from the 1991 census to identify migration patterns at the postcode sector level, and aggregated areas into quintiles based on the Townsend (1987) index of deprivation (labelled most affluent, affluent, average, deprived, and most deprived). They found a propensity for migrants to move from deprived areas to more affluent areas. It was common for the migrants to move from the two deprived quintiles into the most affluent quintile. By contrast, migrants moving from the most affluent areas to less affluent areas occurred in a step-wise fashion. Furthermore, deprived areas were losing population, which in turn caused health inequalities in Northern Ireland to widen. They contended that it was not possible to claim that selective migration produced health inequalities, but that differential migration behaviours may have had an impact on the widening socio-economic gap between areas. In addition, they suggested that because the health profiles of migrants were different to the health profiles of the sick population, it was likely that selective migration had little impact on the overall effect on health outcomes (O'Reilly and Stevenson 2003, p.1460).

In an earlier analysis, the author of this thesis and colleagues (Boyle *et al.* 2004a) investigated the influences that deprivation and population change had on widening the mortality gap in Scotland. Using pseudo-wards derived from Postcode-based CATTs (see Chapter Four for an explanation of CATTs built from Postcodes) and population-weighted quintiles of the Carstairs index of deprivation, we reported a consistent mortality gradient for 1981 and 2001. We grouped the pseudo-wards by the degree of population change: *declining* areas experienced more than 10% decrease in population between 1981 and 2001, *increasing* areas were pseudo-wards that grew in population by more than 10% and the remainder of the pseudo-wards were defined as being *stable*. We found that for the 1999-2001 period, the declining areas experienced the greatest level of inequalities at 1.58. By contrast, those pseudo wards that experienced population growth experienced the smallest mortality gap, with quintile 5 having only 1.47 times greater mortality than quintile 1. We concluded that the widening mortality gap in Scotland was not simply an artefact of population change.

6.3.1. Summary

Although the contemporary studies were undertaken at different geographic scales, there has been no research into the effect that the scale of analysis has on the relationship between population change and mortality in a single study area. This raises the issue of the 'modifiable areal unit problem' (MAUP). There are two components to the MAUP: the 'scale effect' and the 'zonation effect'. The former acknowledges that, as a single study area is divided into sub-areas of different sizes, the relationship between a pair of variables is liable to change. Often, the relationship between two variables will strengthen as the number of zones reduces. The zonation effect refers to the notion that a study area can be divided into the same number of sub-areas using different configurations, and that the relationship between any pair of variables may change as a result (Openshaw 1984).

However, because the CATT2s are consistent through time, it is possible for them to be reliably aggregated into larger geographical zones. Therefore, in this study, the association between population change and mortality is examined for Health Boards, 2001 Council Areas, 1991 Districts, and Scottish Parliamentary

Constituencies.

The review demonstrated that a possible explanation for the relatively high mortality rates in areas of population decline was selective migration, in which less deprived people move out of the deprived areas to more aesthetic environments. Therefore, the second question examined in this Chapter investigates whether deprivation can explain the higher rates of mortality in areas whose population has declined between 1981 and 2001.

6.4. Investigating the Role of Geographic Scale

6.4.1. All Cause Premature Mortality

To investigate the effect that geographic scale had on the relationship between population change and mortality, four different scales were used. The number of zones in the different geographies used (Health Boards, Council Areas, Districts, and Parliamentary Constituencies) was similar to those used in existing studies investigating this relationship.

The analyses for all cause premature mortality are shown in Table 6-1. A stepwise gradient can be seen, whereby the correlation increased as the number of zones decreased. The correlations for the total population were stronger than those observed for males and females separately. Interestingly, the associations were stronger for females than for males at the Council Area and Parliamentary Constituency level, in contrast to the findings of both Davey Smith *et al.* (1998b) and Molarius and Janson (2000). In addition, the correlations for Parliamentary Constituencies in Table 6-1 were considerably lower than the associations reported by Davey Smith *et al.* (1998b) for the whole of Britain. They reported correlations of –0.62 for the total population, -0.68 for males and –0.50 for females. However, the population-weighted correlations in Table 6-1 demonstrate that female mortality had the strongest association with population change at the Parliamentary Constituency level (-0.581), followed by the total population (-0.547) and males (-0.507). Note however, that the results presented in this Chapter only use data for Scotland and comprise 73 Parliamentary Constituencies, whereas Davey Smith *et al.* (1998b) used 292 counties and urban and rural remainders of counties.

	Health Boards	*Council Areas*	*Districts*	*Parl. Const.*
Total	-0.892	-0819	-0.793	-0.547
Male	-0.871	-0.796	-0.784	-0.507
Female	-0.868	-0.806	-0.755	-0.581
Number of Zones.	15	32	56	73

Table 6-1 Correlations between population change and all premature deaths for different geographical aggregations, (all observations significant at 0.01 level)

6.4.2. Cause Specific Premature Mortality – All Adults

The analysis above was extended to consider different causes of premature deaths. In this section, SMRs were calculated for the seven broad disease groups of mortality used in the previous chapter, for the total population aged below 65 years. The correlations between population change and cause-specific premature mortality for all persons are given in Table 6-2. In concordance with Davey Smith *et al.* (1998b; 2001c), there was no association between population change and premature accident mortality. Moreover, accident mortality was the only cause of death that demonstrated a positive association with population change, albeit very small (0.003) and only for Health Boards. Another interesting point regarding the trends observed from accidents was that as the number of zones increased from Council Areas (32) to Districts (56) and Parliamentary Constituencies (73), the strength of the negative association with population change demonstrated a stepwise increase from –0.054 to –0.116 (this is the converse of the gradient for other causes of death). It was expected that the association between mortality and population change would weaken as the number of zones increased – a finding that has been commonly associated with the MAUP (e.g. Openshaw 1984). Table 6-2 shows that the association exhibited a stepwise decrease as the geographic number of zones increased, for each cause of death, except accidents and suicides. The correlation reported for suicides was higher for Council Areas (-0.594) than for Health Boards (-0.563).

	Health Boards	*Council Areas*	*Districts*	*Parliamentary Constituencies*
Accidents	0.003	-0.054	-0.094	-0.116
Stroke	-0.922	-0.740	-0.680	-0.348
Heart Disease	-0.921	-0.831	-0.799	-0.563
Cancers	-0.761	-0.752	-0.721	-0.517
Respiratory Disease	-0.851	-0.770	-0.722	-0.560
Suicides	-0.563	-0.594	-0.561	-0.369
All Other Causes	-0.851	-0.787	-0.755	-0.486
Number of Zones.	15	32	56	73

Table 6-2 Correlations between population change and cause-specific mortality, for all premature deaths (all observations significant at the 0.01 level).

There was a considerable amount of inconsistency when the correlations were ranked for each geographic scale. For example, while stroke mortality was most associated with population change at the Health Board level, the correlations for stroke were ranked fifth for Council Areas and sixth for Parliamentary Constituencies. Similarly, the 'all other causes' category was ranked fourth for Health Boards (r=-0.851), second for Council Areas and Districts (r=-0.787 and –0.755 respectively), and fourth at the Parliamentary Constituency level (-0.486). The ranking of the correlations for respiratory disease and suicides were relatively stable across different scales. For Health Boards, respiratory disease was ranked third (r=-0.851), while suicides were ranked sixth (r=-0.563). These rank positions were maintained for both causes at the Council Area and District levels but each cause increased their ranking by one at the Parliamentary Constituency level. Thus, Table 6-2 shows that respiratory disease was ranked second, with a correlation of –0.560 and the association between population change and suicide was fifth, at –0.486.

6.4.3. Cause Specific Premature Mortality – Males and Females

The associations between cause specific mortality and population change were replicated for males (Table 6-3) and females (Table 6-4), and the same broad patterns found for total premature mortality (Table 6-2) were observed. For example, male accident mortality demonstrated the same weak association with population change. In addition, the association was positive for Health Boards and negative for each other scale, which was consistent with the results for all persons shown in Table 6-2.

For males, suicide mortality was the only cause of death that did not demonstrate a stepwise reduction in the association with population change as the number of zones increased. The Council Area correlation for male suicides (-0.494) was higher than for Health Boards (-0.428). A similar observation was found for female suicides (Table 6-4), in which the Council Area correlation was –0.662, while for Health Boards the association was –0.652. In addition to suicides, the relationship between female cancers and population change was also higher at the Council Area level (-0.654) for Health Boards (-0.547).

Premature Male Mortality	*Health Boards*	*Council Areas*	*Districts*	*Parliamentary Constituencies*
Accidents	0.040	-0.006	-0.061	-0.108
Stroke	-0.816	-0.655	-0.627	-0.300
Heart Disease	-0.911	-0.824	-0.790	-0.528
Cancers	-0.792	-0.744	-0.707	-0.470
Respiratory Disease	-0.783	-0.736	-0.688	-0.472
Suicides	-0.428	-0.494	-0.467	-0.353
All Other Causes	-0.818	-0.757	-0.736	-0.432
Number of Zones.	15	32	56	73

Table 6-3 Correlations between population change and cause-specific mortality, for male premature deaths (all observations significant at the 0.01 level).

Premature Female Mortality	*Health Boards*	*Council Areas*	*Districts*	*Parliamentary Constituencies*
Accidents	-0.062	-0.150	-0.149	-0.115
Stroke	-0.828	-0.626	-0.526	-0.285
Heart Disease	-0.911	-0.788	-0.708	-0.536
Cancers	-0.549	-0.654	-0.597	-0.456
Respiratory Disease	-0.848	-0.713	-0.650	-0.536
Suicides	-0.652	-0.662	-0.547	-0.226
All Other Causes	-0.852	-0.774	-0.718	-0.552
Number of Zones.	15	32	56	73

Table 6-4 Correlations between population change and cause-specific mortality, for female premature deaths (all observations significant at the 0.01 level).

When each cause of death was ranked by its association with population change and by gender, there were some subtle changes to those observed for the all persons, described above. For example, stroke mortality had the strongest correlation for Health Boards for the total population aged less than 65 years (-0.922). In contrast, heart disease showed the most association with population change for both males (r=-0.911) and females (r=-0.911). Stroke mortality exhibited the third strongest association with population change for males (-0.816), while for females the same association was fourth strongest (-0.828).

A further point of interest in the gender specific analyses was that the strength of the relationship between mortality and population change was not consistently higher for males than females (or vice versa), either by cause of death or by geographic scale. Only the correlations for female cancers were lower than for males across all four geographic scales, while the correlations for female accidents were consistently higher than those reported for males, although the associations were small.

For each other cause of death, the trends were more erratic. Respiratory disease was higher for females than males for Health Boards and Parliamentary Constituencies but was weaker for Council Areas and Districts. In most cases, the differences between the associations reported for males and females were relatively small. For example, at the Health Board level, the female correlation was –0.828, while for males the association was –0.816. However, the differences between the correlations for suicides were considerably larger than for other causes of death. For example, the association between male suicides and population change was –0.494 for Council Areas, while for females at the same scale, the correlation was –0.662.

6.4.4. Summary

The results presented above suggested that the relationship between population change and mortality was affected by geographic scale and also by cause of death. Moreover, while Davey Smith *et al.* (1998b) reported that the relationship was stronger for males than for females in their analysis, this was not always the case for all cause premature mortality (Table 6-1). In addition, while the association between female mortality and population change was the weakest observation reported by Davey Smith *et al.* (1998b), the observation for females at the Parliamentary Constituency level (-0.581) was higher than for males (-0.507) or for the total population (-0.547).

Although the correlations observed for accident mortality changed signs at different spatial resolutions each observation was statistically significant ($p<0.01$), largely because the results were population weighted. This observation differed from the report by Davey Smith *et al.* (2001c), who analysed the relationship between population change and a number of specific causes of death for males and females. They found that the association between accidents and population change was not statistically significant for males but not for females in 1981-1980, or 1990-1998, although the relationship did change signs from 0.10 to –0.07 for males. When they controlled for the proportion of the population in low social classes (defined as social Classes IV, V, or unclassified), the relationship was significant and positive for males in both periods (0.24 and 0.19 respectively), and remained negative and not significant among females.

For other comparable causes of death (stroke, heart disease, respiratory disease and suicides), the correlations for males and females at the Parliamentary Constituency level were lower in this study than Davey Smith *et al.* (2001c) reported, based on mortality for the 1990-1998 period. However, similar or stronger correlations were observed at other scales for most causes of death. For example, Davey Smith *et al.* (2001c) found a correlation of –0.67 for male stroke mortality, using their 292 county boroughs and urban and rural remainders of counties. For this study, the correlations ranged from –0.627 for Districts to –0.816 for Health Boards. Similarly, for female respiratory disease the correlations found in this study ranged from –0.848 at the Health Board level to –0.536 for Parliamentary Constituencies. Thus, except for the Parliamentary Constituency level, mortality from respiratory disease demonstrated a much larger association with population change than reported by Davey Smith *et al.* (2001c), at –0.62.

In this study, the relationship between population change and mortality was linear for most of the causes, whereby the correlations were highest at the Health Board level, and decreased in a stepwise fashion as the number of zones increased. However, the correlations for suicides were consistently higher for Council Areas than for Health Boards, and female cancers were also higher at the Council Area than expected. Thus, the findings from this analysis have shown that the association between mortality and population change is affected by geographic scale.

Davey Smith *et al.* (1998b) pointed out that health resources are generally distributed in proportion to population size. They suggested that this approach to resource allocation ignored the fact that those living in places where the population was declining would have worse health experiences than people living in more affluent areas and/or areas where population had grown. Consequently, these areas would require more resources than their population size would suggest. The results presented in Table 6-1 demonstrated that the relationship between population change and mortality varied with geographical scale. Thus, the effect that the redistribution of resources based on population dynamics would have on the general health of residents in poorer areas would be dependent on the scale at which the resource allocations were undertaken. Deciding upon the most appropriate scale at which to consider resource reallocation may not be a simple matter.

6.5. The Role of Deprivation

Davey Smith *et al.* (1998b; 2001c) and Molarius and Janson (2000) used partial correlations to examine the effect that socio-economic circumstances had on the relationship between population change and mortality. For the UK-based studies by Davey Smith *et al.* (1998b; 2001c) the proportion of the population in social class IV, V, or who had an unclassified social class, was used to represent deprivation. They demonstrated that after controlling for social class, the correlations between cause specific mortality and population change were only slightly reduced, and remained statistically significant. Similarly, Molarius and Janson (2000) considered education and income variables and suggested that about one third of the correlation between population change and all cause mortality for males was explained by the percentage of residents with high incomes. Whereas Davey Smith *et al.* (1998b; 2001c) used social class as their marker of socio-economic circumstances, in this study, population weighted quintiles derived from the 2001 Carstairs index of deprivation were used.

6.5.1. Premature Mortality by Population Change Category

In this study, the percentage population change was calculated for males and females separately and combined, for the population aged below 65 years. To demonstate again that declining areas had worse mortality patterns than the stable or growing areas, the CATT2s were divided into three categories. Those CATT2s whose population had declined by 10% or more between 1981 and 2001 were classified as areas of *decline*. Similarly, those CATT2s whose population had grown by 10% or more were labelled areas of *growth*, and all other CATTs were classified as *stable*. Table 6-5 provides the distribution of CATT2s by population change group. Note that the number of CATT2s in each population change group varied for males, females and the total population because gender-specific population change was used in the classification process.

	Under 65 Population		
	Male	*Female*	*Total*
Decline	5,122	5,031	5,093
Stable	2,039	2,276	2,187
Growth	2,896	2,750	2,777

Table 6-5 The distribution of CATT2s by population change category (n=10,057)[1]

Standardised mortality ratios were calculated using all deaths below 65 years of age, for males, females, and all persons, by the population change category. Figure 6-2 shows that in 1999-2001, the areas that had the highest mortality ratios were indeed those CATTs that experienced the most population decline between 1981 and 2001. Moreover, Figure 6-2 demonstrates the expected gradient from areas of decline to areas of population growth. For males, females and the total population, the SMR for premature mortality in the areas of population decline was significantly higher than for the areas of population stability, which in turn was significantly higher than areas of population growth. Within the same population change category, the SMRs for males were not significantly different to the SMRs for females (and vice versa) or significantly different to the SMRs for the total population aged below 65 years.

[1] Note that n=10,057 as the Carstairs index of deprivation could not be calculated for one CATT2 in Glasgow.

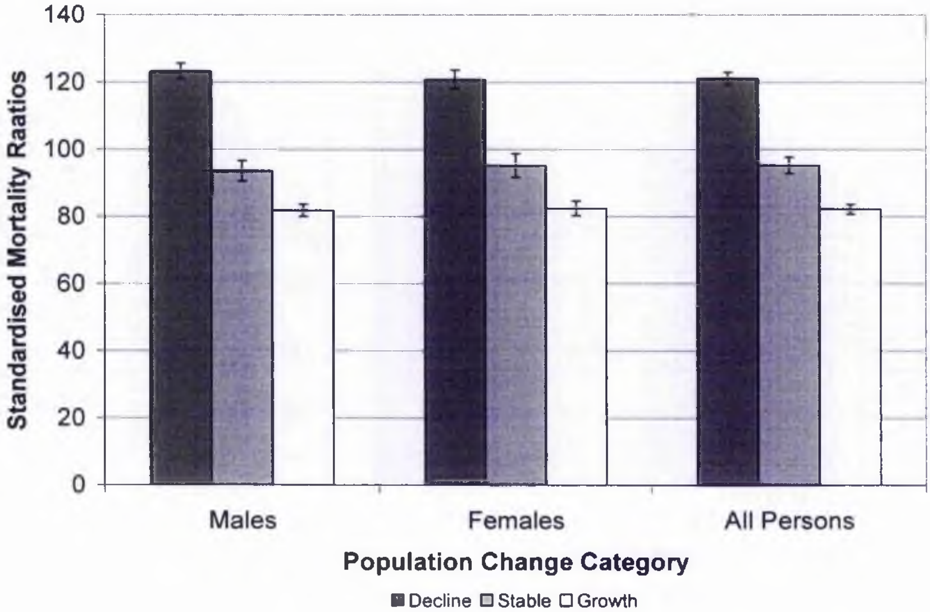

Figure 6-2 Premature mortality for males, females, and all persons by population change category

6.5.2. Premature Mortality by Population Change Category and Deprivation

The previous analysis ignores the socio-economic circumstances of the areas involved. Because areas in decline are also likely to be the most deprived, it is important to test whether this gradient exists, once deprivation is controlled for. In this study, the population weighted quintiles derived from the 2001 Carstairs index of deprivation were allocated to the CATT2s and then reapportioned to the three population change categories, thus providing 15 categories of deprivation/population change CATT2s. Again, SMRs were calculated for all persons aged below 65 years, in addition to SMRs for premature mortality among males and females. Table 6-6 provides the number of CATT2S in each of the 15 categories.

Figure 6-3 shows the distribution of premature mortality in 2001 by population change group and 2001 population weighted deprivation quintile. A clear social gradient is evident for each of the population categories, in which the SMR increased as deprivation also increased. However, given the results shown in Figure

6-2, the population decline category was expected to have higher mortality ratios than the stable population or the population growth categories, but this was not the case. Rather, the population decline category only exhibited significantly higher mortality than the other categories for quintile 2, for all persons and for female premature mortality. Moreover, for all persons and males, the population growth category experienced significantly higher mortality than the other two population change categories in the most deprived areas. Thus, Figure 6-3 suggests that when deprivation has been controlled for, the apparent relationship between population change and mortality shown in Figure 6-2 no longer remains significant.

The observation that the population decline category has the same or better mortality as the population growth category needs further clarification. Returning to Table 6-6 it can be seen that there was a disproportionate number of CATTs allocated to each deprivation quintile. The most deprived CATTS2 were notably more common in the areas of population decline, while the least deprived CATTS2 were more common in the areas of population growth.

The distribution of CATTs was most uneven in the most deprived quintile. Table 6-6 indicates that the population decline category contained 2,016 CATTs, whereas there were only 347 CATTs in the stable population category and 216 CATTs in the population growth category. Note that the deprivation quintiles were population weighted and although the total number of CATTs allocated to each quintile was not equal, the total population within each quintile was approximately one million.

Population Change Category	*Quintile*	*All Persons*	*Males*	*Females*
Decline	1	631	648	641
	2	439	450	434
	3	700	681	694
	4	1,307	1,316	1,297
	5	2,016	2,027	1,965
Stable	1	562	512	593
	2	401	384	402
	3	403	408	432
	4	474	426	475
	5	347	309	374
Growth	1	847	880	806
	2	710	716	714
	3	587	601	564
	4	417	456	426
	5	216	243	240
	Total	10,057	10,057	10,057

Table 6-6 Distribution of CATT2s, by population change group and deprivation quintile

Referring back to Figure 6-2, the expected relationship between the population change categories and mortality were reported. However, when these SMRs were calculated for all persons, the population growth category was based on 2,777 CATTs, of which 1,557 (56%) were allocated to quintile 1 or quintile 2. In contrast, the SMRs for the population decline category comprised of 5,093 CATTs in total, 3,323 (65%) of which belonged to quintile 4 or quintile 5. Thus, Figure 6-3 shows that the relationship in Figure 6-2 was an artefact of the effect of deprivation and once this was controlled for, declining places were shown to do as well as, or better than, areas that were growing, in terms of premature mortality. In addition, Figure 6-2 and Figure 6-3 have suggested that deprivation affects mortality (whereby more deprived areas have higher death rates), but population change, if anything, weakens this relationship for the total population and males.

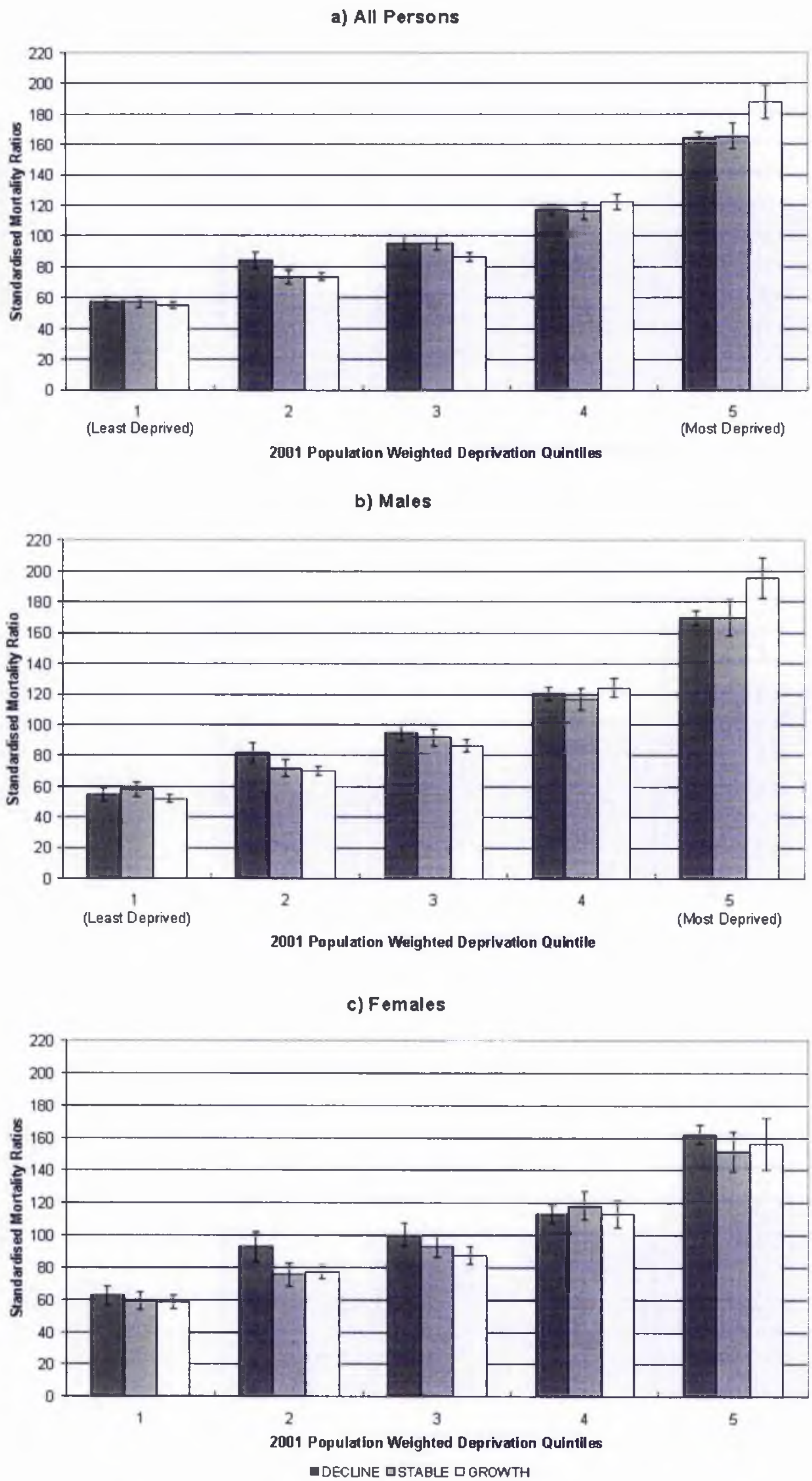

Figure 6-3 Premature mortality by population change category and deprivation quintile

6.5.3. Mortality Inequalities by Population Change Category

An earlier paper (Boyle *et al.* 2004a) used pseudo-wards derived from CATTs created from postcodes (see Chapter Four) to examine the association between population change and mortality, and found that this relationship between could not be fully explained by deprivation. They also examined the widening mortality gap between 1980-1982 and 1999-2001, for areas of population decline, population stability and population growth, using the same criteria that has been used in this study. Mortality inequalities between the least deprived and most deprived quintiles increased from 1.35 in 1980-1982 to 1.58 in 1999-2001. In contrast, relative inequalities between the least and most deprived quintiles in areas whose population increased over the study period rose from 1.4 for 1980-1982 to 1.47 in 1999-2001. Therefore, they concluded that inequalities were widest, and widening in areas whose population was declining over time.

As this Chapter is only concerned with premature mortality between 1999-2001 for population change categories constructed from CATT2s, these results are not directly comparable with the results of Boyle *et al.* (2004a) who examined mortality trends over time. However, the SMRs for premature mortality in the least deprived areas (Quintile 1) and most deprived areas (Quintile 5) for 1999-2001 are shown in Table 6-7 by population change category and gender. In addition, the relative inequalities between the least deprived and most deprived areas have also been provided.

Surprisingly, Table 6-7 shows that the premature mortality gap among the total population was lowest in areas of population decline. Nonetheless, mortality in the most deprived areas was 2.87 times higher than in the least deprived areas. The population growth category demonstrated the widest premature mortality gap, in which the SMR in deprived areas was 3.40 times greater than in the least deprived areas among the total population.

Relative inequalities for premature mortality were also widest in areas of population growth among males and females, but the narrowest relative inequalities were found for the category where the population did not change between 1981 and 2001

(Table 6-7). Mortality was 3.75 times higher for males living in the most deprived quintile compared with the least deprived quintile in areas whose population had grown over time. Among females, mortality in the population growth category was 2.68 times higher in the most deprived quintile than the least deprived quintile. In areas of population decline, relative inequalities were highest among males, at 3.11, while for females the ratio of inequalities was 2.60.

Population Change Category	*Quintile 1*	*Quintile 5*	*Ratio*
All Persons (0-64 years)			
Decline	57.36	164.73	2.87
Stable	57.47	165.52	2.88
Growth	55.20	187.86	3.40
Males (0-64 years)			
Decline	54.58	169.73	3.11
Stable	58.24	169.98	2.92
Growth	52.11	195.65	3.75
Females (0-64 years)			
Decline	62.26	161.94	2.60
Stable	59.28	151.60	2.56
Growth	58.42	156.39	2.68

Table 6-7 Premature mortality inequalities (1999-2001) for all persons, males and females by population change category

Figure 6-3 showed the social gradient of premature mortality for males, females and the total population. The gradient highlighted that although mortality for the population growth category in the least deprived quintile was not significantly different to areas of stability or population decline, the SMRs in the most deprived quintile for the total population and for males were significantly different to the SMRs for the other two population change categories in the most deprived quintile.

In summary, this Section has shown that for premature mortality in 1999-2001, relative inequalities between the least deprived and most deprived quintiles were highest within areas whose population had increased between 1981 and 2001.

Furthermore, for males and females, areas whose population remained relatively stable demonstrated the narrowest mortality gap. These results do not correspond to our earlier results of Boyle *et al.* (2004a), which found that areas of population decline had the widest relative inequalities in 1999-2001. Both studies used the same criteria to construct the population change categories. However, the earlier analysis was undertaken for 973 pseudo-wards, which were aggregations of CATTs constructed from postcodes, while the results presented in this analysis were based on the 10,058 CATT2s. Furthermore, they presented inequalities in deaths occurring among the total population, while the results presented here refer to premature mortality.

Our earlier research (Boyle *et al.* 2004a) suggested that the higher rates of mortality in areas of decline might have been due to the healthy migrant effect. The results presented here may suggest that the individuals who remain in deprived areas where the population is declining are proportionally more likely to be of post-retirement age. Furthermore, this study supports our earlier recommendation: that deprivation rather than population size should be considered as an important dimension in the allocation of health and social resources. Therefore, the evidence from this research suggests the current Scottish approach of redistributing resources based on deprivation, are more equitable than population-based alternatives. In Scotland, resources are allocated according to the Arbuthnott Index (Scottish Executive Health Department 1999). This index is a composite of four standardised variables, and considers premature mortality, the proportion of households with 2 or more 'deprivation' indicators (derived from the 1991 census), proportion of the population of working age receiving the unemployment benefit; and the proportion of the population aged 65 and over receiving income support.

6.6. Conclusions

This chapter has extended the existing literature by first exploring the association between premature mortality and population change across four different spatial aggregations. In addition to premature mortality from all causes, this chapter investigated the relationship for accidents, stroke, heart disease, cancers, respiratory disease, suicides and all other causes of death combined. The four geographic scales observed were (pseudo) Health Boards, (15 zones), Council Areas (32 zones), Districts (56 zones) and Parliamentary Constituencies (73 zones).

It was found that for most causes of death, the decrease in the association between population change and mortality followed a linear trend as the number of zones increased. Suicides for all persons, males, and females, and female respiratory disease were exceptions to this trend. For these causes, the Council Area correlations were higher than those reported for the Health Board. Accident mortality demonstrated neither a consistent relationship nor a strong relationship with population change. One might have expected the relationship between population change and mortality (from all causes and for specific causes) to be stronger for men than for women, but this was not always the case. In fact, for Parliamentary Constituencies, premature female mortality from all causes exhibited the strongest relationship. Moreover, the associations for female mortality were stronger than for males for most causes of death, and at most geographic scales.

The most common explanation for the negative association between population change and mortality has been the 'healthy migrant effect', in which people in good health are more likely to have the ability to leave places with unfavourable social conditions than those with poor health (e.g. Davey Smith *et al.* 1998b; O'Reilly 1994). Therefore, it was expected that the areas that declined the most between 1981 and 2001 would demonstrate the highest mortality. Indeed, Figure 6-2 showed that this was the case when the CATT2s were apportioned to population change categories based on 10% population decline or growth.

However, a number of social, economic, political, and environmental factors can influence the decision for a migrant or group of migrants to settle at a particular location. Traditionally, economic and employment factors were cited as the key factors driving migration. Findlay and Rogerson (1993) demonstrated the importance that inter-regional and inter-city migrants placed on pull factors associated with the quality of life, rather than on economic factors. A further interesting finding from their analysis was that the young and elderly migrants both identified health service provision as being an important consideration in the decision of where to migrate. Thus, health service provision was identified as the most important factor for the elderly migrants, while it was the second most common dimension for young migrants.

The association between population change and mortality was clearly affected by the geographic scale. For example, the relationship between total premature mortality and population change between 1981 and 2001 at the Health Board level was much stronger (-0.892) than the relationship at the Parliamentary Constituency level (r=-0.547). Therefore, these results support the recommendations of Davey Smith *et al.* (1998b); that areas whose populations are declining should be provided with extra resources to help reduce the mortality gap.

In the contemporary literature investigating the association between population change and mortality, partial correlations have been regularly used (Davey Smith *et al.* 1998b, 2001c; Molarius and Janson 2000) to control for the effect of socio-economic circumstances on the observed correlations. In this chapter, the effect of deprivation was investigated using an alternative approach. The CATT2s were allocated three population change categories (decline, stable and growth) and were also assigned to a 2001 population weighted deprivation quintile, following the criteria used by Boyle *et al.* (2004a). Figure 6-3 demonstrates that the areas with declining populations failed to exhibit our earlier finding (Boyle *et al.* 2004a), that higher mortality than those areas whose populations grew between 1981 and 2001. Rather, the SMR for the declining population category was only significantly higher for quintile 2. Surprisingly, the areas of population growth demonstrated the highest SMR in the most deprived quintile. Furthermore, this study showed that the population growth category experienced the widest mortality gap for 1999-2001 among the total population and for males and females.

This research has found that while areas that suffered population decline between 1981 and 2001 had the highest mortality rates, the relationship was an artefact of deprivation circumstances. It could be argued that the healthy migrant effect, which has commonly been used to explain the relationship between population change and mortality (e.g. Davey Smith *et al.* 1998b; Molarius and Janson 2000; Boyle *et al.* 2004a), does not hold for premature mortality. However, as Boyle *et al.* (2004a) found that declining areas had higher mortality when deaths across all ages were considered, the results might suggest that the healthy migrant effect operates among post-retirement age groups.

Finally, it should be noted that the analyses conducted for this chapter were only made possible through the creation of the CATTs. While the four geographic scales used were only approximations to the official higher geographies, they ensured that data from the 1981 and 2001 censuses could be analysed reliably. This chapter has therefore demonstrated the versatility of the CATTs and their application for health research. The following Chapter provides a further example of the benefits of CATTs, when the widening suicide mortality gap, first noted in the previous chapter, is examined in more detail.

7. The Widening Suicide Gap 1981-2001

7.1. Introduction

Although suicides account for a small proportion of deaths per annum in Scotland, Chapter Five demonstrated that this was the only cause of death that increased over time. Furthermore, Chapter Five also showed that the suicide gap between the least and most deprived quintiles had widened significantly, regardless of gender, or the method used to construct the quintiles. The reduction of deaths from suicide features in the health inequalities portfolio of many countries (The Scottish Executive 2002b; Ministry of Health 1998; Department of Health 2002). Recent research (Gunnell *et al.* 2003) demonstrated that suicides were increasing for the young men, while the suicide rate has been falling for older men. Therefore, it is timely to investigate the changing geographical patterns of suicide mortality in Scotland. In doing so, this chapter provides another opportunity to demonstrate the flexibility of the CATTs.

7.1.1. The Sociology of Suicide

Although suicide has always been considered to be a highly individual act, Durkheim (1897) believed that the 19th Century explanations for suicide (i.e. that 'insanity' was most associated with suicide) were unsatisfactory. To develop alternative theories of suicide, based on social behaviour rather than individual behaviour, Durkheim analysed suicide data from various European countries. First, he demonstrated that countries exhibited relatively stable suicide rates, between 1866-1870, 1871-1875 and 1874-1878. For example, the suicide rate in Italy was consistently the lowest of the 11 countries examined, ranging between 30 per million for the first period to 38 per million in the last period.

In addition to differences between countries, suicide rates were also found to vary amongst population groups. For example, fewer Roman Catholics than Protestants committed suicide, while being married reduced the likelihood of suicide and being educated was positively associated with suicides. Countries that were at war also experienced fewer suicides. Furthermore, religion was considered to be a more important factor than education, since the Jewish population generally had high levels of education, but considerably lower suicide rates than expected. These findings led to Durkheim defining four distinct types of suicide: *egoistic, altruistic, anomic* and *fatalistic*. *Egoistic* suicides were those that resulted from individuals that were poorly integrated with society. In addition, they were also most common and contributed most to the total suicide rate. Whereas the Roman Catholic Church encouraged a sense of community, by following age-old rituals, members of the Protestant Church were encouraged to develop their own religious ideals. Thus, as the Protestants had more freedom, resulting in poorer social integration and consequently higher mortality than Roman Catholics, their suicides were examples of egoistic suicides. In contrast, *altruistic* suicides occurred in extremely well integrated environments, where individuals would die as an act of duty or respect to others. *Anomie* suicides occurred in localities that were experiencing rapid social change, which in turn disrupted the social norms and values, and consequently reduced the degree of social regulation. By contrast, *fatalistic* societies occurred in oppressive environments, such as prisons.

Durkheim (1897) divided the factors associated with anomic suicide further, recognising the apparent importance of suicides associated with rapid social change. Thus, anomic suicides were categorised into acute or chronic and domestic and economic. *Acute economic anomie* was associated with the inability of traditional institutions, such as the Church, to regulate the needs of society. In contrast, *acute domestic* anomie was associated with suicide resulting from the inability to adapt to social change at the individual level, of which widowhood would be an example. *Chronic economic* anomie occurred from social deregulation over long periods of time, and recognised that happiness was not a product of wealth alone. Durkheim's example of chronic economic anomie was the industrial revolution since the suicide rate was higher among the wealthy than the poor for the duration of the revolution. Durkheim considered marriage to be an institution in which each spouse defined expected goals and regulations, and was therefore categorised as c*hronic domestic* anomie. These goals and expectations provided males with a sense of stability and reduced the risk of suicide. In contrast, married females felt pressured by the goals and expectations placed upon them, and therefore higher suicide rates were more common among married females.

In addition to the four classifications of suicide (egoist, altruistic, fatalistic, and anomie), Durkheim (1897) explored the theories of imitation and suicide contagion, which referred to some localities having a greater propensity to suicide than others. Imitative suicides were instances where the two or more suicides took place relatively close (in time and/or space) and where the same mechanism (e.g. hanging) was used to complete subsequent suicides. Furthermore, Durkheim (1897) suggested that imitative suicides did not raise the overall suicide rate excessively, that such instances were intermittent and that the radius of an imitative suicide cluster was typically small.

In contrast, contagion theory was discussed in terms of spatial diffusion, in which the suicide rates would be highest in large cities and reduce (inversely) with distance. Durkheim (1897) demonstrated the spatial diffusion of suicide across French districts (arrondissement) between 1887-1891, in which the rates were considerably higher in the North, around the former Ile-de-France extending to Champagne and Lorraine, and diminished with distance from this central cluster.

Contemporary research focussing on imitative and contagious suicide theories has typically been undertaken by the medical fraternity, rather than by geographers who have tended to focus on the analysis of anomic suicide. Imitative suicides are more common among adolescents than adults, and have often been associated with the reporting of suicide in the media, or follow the suicide of a celebrity.

Following a review of literature regarding suicide contagion, Joiner (1999) identified two broad types of cluster. First, a *point cluster* was defined as a collection of suicides that are proximal in time and/or space, often within an institutional setting such as a hospital, prison or school, and there was also evidence of social contiguity. Although a cluster of suicide is difficult to define, Berman and Jobes (1991) suggested that 3 or more suicides within close spatio-temporal proximity should be defined as a cluster. Brent *et al.* (1989) reported a cluster in which 2 high school students committed suicide in 4 days of each other. They also reported that over an 18 day period, 23 students reported suicidal thoughts and a further 7 students attempted suicide. There was a greater propensity for the suicide victims' friends to develop suicidal symptoms, providing evidence of social contiguity.

Wilkie *et al.* (1998) described the clustering and the potential contagion of suicide and attempted suicide in a geographically isolated community of aboriginal Canadians (first nationals). Over the course of 90 days, six young people aged between 14 and 25 committed suicide, an exceptionally high number given that the total population of the community was approximately 1,500. Three of the six victims were friends and of similar ages, and five of the victims died by hanging. Within the community, there was much speculation regarding the cause of the suicide cluster, but in the main the reasons were anomic. For example, cited factors included: a recently opened baseball field; the local Council; the lack of Christianity; and the negative influences that television and other forms of media had on traditional beliefs and cultural behaviours.

Second, Joiner (1999) defined suicides that were apparently related to media reports of suicide as *mass clusters.* Unlike point clusters, mass clusters tended to cluster in time and not space. For example, Gould and Shaffer (1986) examined trends in suicide attempts among teenagers in New York in the two weeks prior to and two weeks following four fictional films which portrayed suicide were broadcast on television, and found that attempted suicides increased significantly following the broadcasts. In the two weeks following three of the four films being broadcast, there was also a significant increase in the rate of completed suicides.

In the UK, Hawton *et al.* (2000) showed that the number of suicides in England and Wales, and the number of admissions to hospital in Oxford resulting from deliberate self harm (DSH), increased following the death of Diana, Princess of Wales. Moreover, while there was not a significant increase in suicides in the week immediately following her death (compared to trends for 1992-1996), in the month following Diana's funeral, the overall mean weekly suicide rate was significantly higher than expected. Among women, there was an increase of 33.7% while for men the rate increased by 12.5%. Whereas no significant increase in suicides occurred during the week immediately following the death of Diana, there was a (marginally) significant increase (44.3%) in admissions to hospital for deliberate self-harm, particularly among women, with 65% more female DSH admissions than expected.

7.2. Suicide Trends in an International Context

There are very few studies that compare the suicide patterns of Scotland with other countries around the world. Often, this is due to the data sources used in the analyses, and some organisations (e.g. European Statistical Office of the European Commission (EUROSTAT), United Nations) consolidate mortality counts from Scotland with those of the other constituents of the United Kingdom (e.g. Chishti *et al.* 2003). However, Leon et al. (2003) compared the suicide rate for Scottish males and females aged between 15 and 74 years for the period 1991-1995 with 16 other countries in Western Europe. Among males, Scotland was ranked 11th and had a suicide rate of 22.5 per 100,000. Similarly, Scottish females were also ranked 11th, with a rate of 6.8 per 100,000.

The Australian Institute for Suicide Research and Prevention (2003) examined trends in suicides between 1960 and 2000 for 32 countries, classified as 'Old World', 'New World', 'Western Europe', 'Eastern Europe', 'Southern Europe' 'Scandinavia', 'Latin America' and 'Asia'. Suicide rates were calculated for males, females and all persons, for five age groups (0-14, 15-24, 25-44, 45-64 and 65+). Scotland was categorised as part of the 'Old World', along with England and Wales, Northern Ireland and Ireland.

The authors used the most recent data available for each country (typically between 1997 and 2000) and listed the rank position for males and females in each age group except 0-14, as these data were considered to be unreliable. In their analysis position '1' was allocated to the country with the highest death rate. Table 7-1 shows Scotland's suicide rank position for males and females across different age groups, and also reports the highest and lowest suicide rates for comparison. Scottish males aged 15-24 were ranked 8th with a suicide rate of 27.9 per 100,000, just under half the rate of the Russian Federation, but nearly four times greater than the rate in Portugal. In addition, the rate for males in Scotland was approximately 3.5 times higher than the rate for England and Wales, whose rate was 8.0 per 100,000 and ranked 28th out of 33 countries.

Among males aged between 25 and 44, Scotland's rank position worsened slightly to 7th position with a rate of 32.5 per 100,000, and was 4.94 times higher than for males in the same age group living in Portugal. Table 7-1 also shows that the suicide rate among Scottish males decreased with age. Consequently the rank position improved, first to 24th position for males in middle age (45-64) with a rate of 21.2 per 100,000, and then to 30th position for males aged 65 years or older (13.2 per 100,000). However, while the suicide rate for males of pensionable age was the fourth lowest of the 33 selected countries, it was still 1.69 times greater than the rate of males in Northern Ireland. The rate for elderly men from England and Wales was ranked one position higher than for Scottish males (31st) with a rate of 11.6: the smallest differential between both countries for males in the analysis by the Australian Institute for Suicide Research and Prevention (2003).

Table 7-1 shows that the rank position for suicide among females in Scotland was much better than for males in the younger age groups, which one might expect since suicide has been increasing for younger males but decreasing for younger females. In spite of having a significantly lower suicide rate than males, the suicide rate for females between 15 and 24 years (5.7 per 100,000) was still nearly six times higher than the rate for females of the same age group in Portugal. In the same way that the Eastern European Countries consistently had the highest suicide rates for men, China exhibited the highest suicide rate across all ages, with rates between 13 times (45-64) and 32 times (15-24) higher than the suicide rate in the country with the lowest suicide rate.

For Scottish females, the rank position increased with age, although the suicide rate was higher among females between 25 and 44 (8.6 per 100,000) than for females between 15 and 24 (5.7 per 100,000). Between the ages of 15 and 65 the lowest suicide rates were located in Southern Europe (15-44: Portugal, 45-64: Greece), and ranged between 1.0 and 1.9 per 100,000, suggesting that the suicide rate in Scotland was relatively high in spite of it's rank position. For females aged 65 years and older, the rank position for females was 31st at a rate of 3.4 per 100,000, while Northern Ireland demonstrated the lowest suicide rate for this age group, at 2.3 per 100,000. Thus, despite having the third lowest suicide rate, there were 1.5 times more suicides among Scottish females aged 65 years and older, than females from

Northern Ireland in the same age group. The suicide rate for Scottish females 65 years and older was the only rate (among males and females) that was lower than the rate in England and Wales (3.8 per 100,000).

Age Group	*Scotland Rate (Rank)*	*Lowest Rate (Country)*	*Highest Rate (Country)*
Males			
15-24	27.9 (8)	3.7 (Portugal)	57.7 (Russian Federation)
25-44	32.5 (7)	6.6 (Portugal)	90.0 (Russian Federation)
45-64	21.2 (24)	7.6 (Greece)	145.2 (Lithuania)
65+	13.2 (30)	7.8 (Northern Ireland)	94.8 (Russian Federation)
Females			
15-24	5.7 (13)	1.0 (Portugal)	32.1 (China)[1]
25-44	8.6 (14)	1.1 (Portugal)	32.1 (China)
45-64	5.3 (25)	1.9 (Greece)	25.6 (China)[2]
65+	3.4 (31)	2.3 (Northern Ireland)	63.1 (China)[3]

Table 7-1 Scotland's rank position for suicide rates per 100,000, by age group and sex (Source: Australian Institute for Suicide Research and Prevention, 2003)

In addition, the authors also graphed the trends in suicides between 1980 and 2000, and found variation in age group trends between the different countries. For example, the Old World countries (England and Wales, Scotland, Northern Ireland and Ireland) demonstrated increases in suicide rates among the male population aged between 15 and 24, except for England and Wales, which remained relatively stable. In contrast, Sweden, Denmark, Austria, Germany and Switzerland showed steady declines over time (The Australian Institute for Suicide Research and Prevention 2003).

In summary, this Section has demonstrated that the suicide rate in Scotland is among the highest in Western Europe, particularly for males aged between 15 and 44 years. Furthermore, this Section has demonstrated that the suicide rate among males is substantially higher than for females, across all age groups. One might have expected China and countries from the former Eastern Bloc to have high rates of

[1] China: 15-34 years
[2] China: 35-59 years
[3] China: 60-84 years

suicide due to their economic conditions and political regimes. However, that Portugal had the lowest suicide rate for males and females aged 15-44 was surprising, since Leon *et al.* (2003) reported that Portugal had similar mortality and life expectancy experiences to Scotland. The following Section compares recent suicide trends in Scotland with the experiences of the other constituents of the United Kingdom.

7.3. Recent suicide trends in the UK

The suicide rate in England and Wales fluctuated considerably during the first half of the 20th century, decreasing dramatically during the two World Wars, and peaking during the Depression during the 1930s. Following World War II, the suicide rate continued to fluctuate, peaking (to a lesser extent) in the early 1960s. Since the 1970s a major divergence in the trend has occurred, in which rates for young males (<45 years) have steadily risen, while the rates for older males decreased. The suicide rate for females was consistently lower than for males although they experienced the same peaks and troughs in rates as males. Unlike males, however, by 1990 older females (>45) continued to have higher suicide rates than younger women (Charlton *et al.* 1992).

McClure (2000) reviewed the suicide rates between 1960 and 1997 in England and Wales by the method of suicide, for males and females separately. Among males, the rates decreased between 1960 and 1997 for suicide from poisoning by solid or liquid substances, with a sizeable reduction (43%) between 1975 and 1990. Poisoning by gases (other than domestic gas) increased by 330% between 1975 and 1990, after which the rate reduced from 43 per million to 22 per million in 1997. Notably, suicide from motor vehicle exhaust emissions reduced from 41 per million in 1990 to 16 per million in 1997. Death by hanging and/or strangulation was the only category examined by McClure that increased consistently between 1960 and 1997 during which time the rate increased by 48%.

During the 1960s and early 1970s, suicides by solid and liquid poisoning and by hanging or strangulation increased for females. However, between 1975 and 1990 the rate for suicide from solid and liquid poisoning reduced by 58%, while the rate for hanging and strangulation suicides declined by just 3%. During the 1990s female suicides resulting from poisoning by gases other than domestic gas reduced by 41%, while vehicle emission related suicide decreased by 60%. For both sexes, the suicide rate from poisoning by domestic gas reduced from over 40 per million for females and over 60 million for males in 1960 to a negligible (~ 1 per million) rate in 1997.

Kreitman (1976) showed that the reduction in suicides by domestic gas inhalation resulted from the transition from coal gas supply to natural gas supply from the North Sea, which took place between 1964 and 1972. In 1957 the domestic (coal-based) gas supply comprised approximately 14% of carbon monoxide, which reduced to 12% in 1968 and reduced further to below 1% in 1972. Johns (1977) showed a similar reduction in the suicides associated with the prescribing of barbiturates between 1959 and 1974, which also contributed to the reduction of suicide by poisoning by solids or liquids. Kendell (1998) suggested that the reduction in suicide by vehicle exhaust inhalation was due to the introduction of catalytic converters on motor vehicles. Since 1st January 1993 all new petrol vehicles in the UK were required to have catalytic converters fitted to reduce carbon monoxide emissions in order to conform to European Law. Kendell showed that the number of suicides due to poisoning by other gases and vapours (which included motor vehicle inhalation) fell from 97 in 1992 to 63 in 1997 for males. Poisoning by other gases or vapours was considerably less common for females, nonetheless the number of these suicides reduced from 11 in 1992 to just 6 in 1997.

7.3.1. Social, Economic, and Political Environments and Suicide

Unemployment could be argued to be associated with anomic suicides. Platt (1984) provided a comprehensive review of research regarding the association between unemployment and suicide and parasuicide. Four broad groups of analyses were reviewed: individual cross-sectional; aggregate cross-sectional; individual longitudinal; and aggregate longitudinal, firstly with regard to completed suicide, then by parasuicide. He concluded that the cross Sectional studies at the individual level showed higher rates of parasuicide among the unemployed than the employed, although the association was less apparent for completed suicide. Similarly, there was inconsistent evidence in the review of aggregate cross sectional studies of suicide, but for parasuicide there was a consistently strong association with unemployment. In contrast, the individual based longitudinal analyses revealed that an elevated risk of suicide was related to unemployment, job instability, and occupational problems. The aggregate longitudinal studies reviewed showed a significant and positive relationship between suicide and unemployment[4] in the United States, but in Great Britain the association between unemployment and suicide varied over time and between authors. For example, Swinscow (1951) used count data from Great Britain (rather than rates) between 1923 and 1947 and for males, showed a strong correlation between the number of suicides and the number unemployed, but the relationship did not hold for females. Brenner (1979) covered a similar period (1936-1976) and showed a negative association between mortality from all causes and unemployment. Similarly, Kreitman and Platt (1984) found a negative association between unemployment and suicide for the period 1955-1980. However, they too found that when their data was divided into shorter time periods, the relationship between suicide and unemployment varied immensely. Between 1955 and 1963 the relationship was positive but not significant, was negative and significant for the period 1964-1972, and was both positive and significant for 1973-1980.

Crombie (1989) also found a significant correlation between suicide and unemployment among men (0.81, p=0<01) in Scotland at the national level. However, no significant relationship was found for females, or for males and females at the Health Board and/or local government district level. Crombie suggested a number of possible explanations for the discrepancy between the national and regional rates. First, the net unemployment rates for Health Boards and local government districts were based on large areas and areas with similar net rates could have represented a different (absolute) number of residents unemployed. Second, the effect that unemployment had on an individual was dependent on opportunities of re-employment; therefore the closure of large organisations was suggested to have a greater effect than loss of employment within a smaller business. His third suggestion was that the national unemployment rate was a suitable marker of recession and that some other factors associated with recession affect the rate of suicide.

[4] In some studies, an associated measure of economic recession was used.

Lester *et al.* (1997) examined differences in the suicide rates for males and females between England and Wales, Scotland, Northern Ireland and Ireland between 1960 and 1990. Over the 30-year period, the rates for females decreased in England and Wales and Scotland, but increased in Ireland and Northern Ireland. The rates decreased among males in England and Wales, but increased for the remaining areas. The authors used the unemployment rate, marriage rate and birth rate as explanatory parameters in a multiple regression model in an attempt to explain these inter-country differences. The unemployment rate was positively associated with male suicide, significantly so in Scotland (0.460, $p<0.05$) and Northern Ireland (0.693, $p<0.05$). Among females however, unemployment was negatively associated with suicide in England and Wales (-0.258, $p<0.05$) and Scotland (-0.148, $p<0.05$), but in Ireland and Northern Ireland the association was neither significant nor positive.

In his conclusions, Platt (1984) stressed that although an association between suicide and unemployment existed, none of the literature provided enough evidence to suggest any direction of causation. Furthermore, he emphasized that in a majority of the studies many of the suicide victims had mental health problems. Platt was dissatisfied with the interpretation from cross Sectional studies of individuals that unemployment leads to psychiatric illness, which in turn leads to suicide.

His alternative model (Figure 7-1) recognised that while psychiatric illness and suicide were directly associated, while also appreciating that an individual with a psychiatric illness was at risk of becoming unemployed, which in turn could provide a pathway to suicidal behaviour. Similarly, at an aggregate level, economic conditions hold a similar position to psychiatric illness, in that an unstable economic climate may have initialise self-harm or suicidal behaviour, but was more directly associated with elevated psychosocial stress levels.

Other researchers have supported the association between psychiatric illness and suicide in Figure 7-1. For example, Hawton (1987) estimated that between 10% and 15% of individuals with schizophrenia and 15% of individuals with affective psychosis committed suicide in Britain. In an anecdotal analysis, Brent *et al.* (1989) found that 75% of the adolescents that either committed suicide or had suicidal thoughts had at least one major psychiatric disorder. Recently, Rihmer and Kiss (2002) reported that major depressive disorder is the leading cause of suicide.

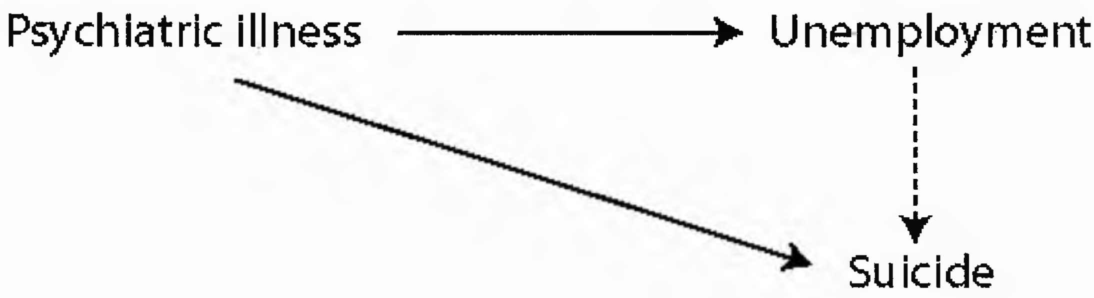

Figure 7-1 The relationship between psychiatric illness, unemployment and suicide (from Platt 1984, p.109)

McLoone (1996) investigated the changes in suicides for men and women by age group and deprivation. Scottish postcode sectors were categorised into three groups, based on the Carstairs index of deprivation (Carstairs and Morris 1991): 'affluent', 'average', and 'deprived', and McLoone showed that between 1981-3 and 1991-3, the suicide rate had risen by approximately 66% for males aged 15-29, from 17.8 per 100,000 to 29.6 per 100,000. While there was a moderate increase for females in this age group, the rate for females aged 30 years and older decreased from 14.1 per 100,000 to 10.2 per 100,000. In addition, the suicide rates that McLoone reported, by gender, age and method of suicide, were consistently lower for the 'affluent' areas than for 'deprived' areas.

Congdon (1996) suggested that the traditional deprivation indices (e.g. Townsend 1987; Jarman 1983) did not fully capture Durkheim's (1897) notion of anomie, and used three alternative measures derived from the census to construct an 'anomie index' to explore suicides and parasuicides (attempted suicides) in London. The anomie index, also known as an indicator of social fragmentation, comprised of levels of non-married adults, one-person households, private renting and migration. These variables were obtained from the 1991 census and standardised with equal weighting, to calculate a total score. Congdon compared the predictive power of the anomie index with the Townsend index and found that male parasuicides were strongly influenced by deprivation, while female parasuicides correlated most strongly with the anomie index.

An ecological study by Gunnell *et al.* (2003) used an extensive list of health, social and economic variables that had previously been shown to be associated (negatively and positively) with suicide, to explore the changing patterns of suicide by age and sex between 1950 and 1998. Many of these variables were strongly inter-correlated (>0.80). Nonetheless, paying particular interest to the two age groups that had demonstrated the largest divergence from the trends (25-34 and 60+), the authors found different social and economic factors had different influences for males and females. Moreover, these factors also varied between young and old male and/or female populations. For example, the results from time-series analyses suggested that while divorce was positively associated with an increased risk of suicides in young males (25-34), divorce had a significant negative effect on young females. However, when deaths by gassing or overdosing were omitted from the analysis, the negative effect on females was not maintained. When the authors modelled all older male suicides, variables representing total male unemployment, alcohol consumption, cirrhosis mortality and the ratio of religious to civil weddings heightened the risk of suicides, while the proportion of females in the total workforce reduced the suicide rates. In contrast, all older female suicides risks were adversely affected by alcohol consumption, while having a strong female workforce, being married and high levels of GDP reduced female suicide risk. Thus, their findings highlighted the possibility that some of the societal processes underlying the variations in the age-sex specific suicide trends affect individuals differently throughout the life course.

While Gunnell *et al.* (2003) used a number of different data sources for their analyses; variables from the decennial censuses have also been used extensively to investigate the relationship between socio-economic status and suicides. For example, Griffiths and Fitzpatrick (2001a) used occupational social class to demonstrate the suicide gradient for men aged 20-64 years for England, Wales and Scotland, and by region for the 1991-1993 period. They demonstrated that there was a clear social gradient, with more suicides among the lower social classes. Scotland had the widest inequalities, while Wales had the smallest suicide gap. Another interesting finding was that the mortality gradient did not demonstrate a stepwise increase across the social classes, in their analyses of regional suicides. For example, whereas suicides increased consistently across the social classes in the

North East, the trend for the South West of England was more varied. Nevertheless, more suicides occurred in social class V than social class I in all regions.

Whitley *et al.* (1999) compared the association of the Townsend Score, Congdon's (1996) social fragmentation index, and abstention from voting, with suicides and other causes of death between 1981 and 1993 across the 633 Parliamentary Constituencies in Britain. They found that areas with higher levels of social fragmentation exhibited higher rates of suicides than deprived areas, particularly for young males. Moreover, when they controlled for deprivation, the strength of the association of suicides with social fragmentation remained. In contrast, while deprivation was associated with suicides, the relationship weakened considerably after controlling for levels of social fragmentation. Thus, the authors concluded that, at the Parliamentary Constituency level, suicides were more strongly associated with measures of social fragmentation than with poverty. In contrast, however, they found that all other causes of death (combined) were more strongly associated with deprivation than with social fragmentation.

Dorling and Gunnell (2003) deconstructed the social fragmentation index, and analysed trends in suicides between 1980 and 2000, for men and women across six different age groups (15-24, 25-34, 35-44, 45-54, 55-64 and 65+). They found that the three variables (proportions of in-migration, single person households and unemployment) were powerful explanatory variables for predicting suicide rates for Parliamentary Constituencies in Britain. More importantly, however, the effect that the three variables had on predicting suicides changed throughout the lifecourse. For example, the relationship between suicide and unemployment peaked for males and females between the ages of 25 and 34, reducing to near unity between 45 and 54 and reducing considerably in older age. In contrast, living in areas of high proportions of single men and women below the age of 34 reduced suicide rates, but increased risk slightly among older ages. Migration was also considered beneficial for the younger age groups, but was shown to pose greatest harm to men and women between the ages of 55 and 64, before reducing slightly in older age.

The analysis by Dorling and Gunnell (2003) also revealed four significant trends in the relationship between the three social variables and suicides. For men, being young (<35) and living in areas with a predominantly single population was more beneficial in the 1990s than in the 1980s. Furthermore, areas with a high proportion of migration increased suicide risk for males aged 55-64, and the effect increased over time. For women below 25, living in areas with a high single population was more beneficial in the 1990s than in the 1980s. For those women between 25 and 34, an adverse effect was observed in both periods, but was notably greater in the 1990s. Their final observation was that for all people aged between 35 and 44, living in areas with a high proportion of males out of work was related to increased suicides, and was worse in the 1990s than in the 1980s.

The negative binomial model used by Dorling and Gunnell (2003) to estimate the count of suicides for each Parliamentary Constituency in Britain was robust. Results from their model reported a correlation between observed suicides and expected suicides of 0.856. They listed the 20 Parliamentary Constituencies across Britain that their model had over-predicted suicide the most, as well as the 20 Parliamentary Constituencies where the number of suicides were under-predicted the most by the model. The model did not over-predict suicide in any of the Scottish Parliamentary Constituencies, rather 11 out of the 20 Parliamentary Constituencies for which the model under-predicted suicides were located in Scotland. Of these 11 Constituencies, four were located within Glasgow (Shettleston, Springburn; Anniesland, and Maryhill) while the remaining Parliamentary Constituencies (Inverness East; Nairn and Lochaber; Ross, Skye and Inverness West; Caithness, Sutherland and Easter Ross; Western Isles; Banff and Buchan; Argyll and Bute; and Central Fife) were more rural areas, except the Central Fife Constituency, which was more suburban than rural.

Middleton *et al.* (2003) examined urban-rural trends in suicide among males and females aged between 15 and 44 years, between 1981 and 2001 in England and Wales, and reported similar results. In the UK, 'rurality' is not clearly defined and so the authors used two different measures of rurality – population density and population potential. The population density was simply the proportion of the population per square kilometre, while population potential was an index of geographic remoteness. Thus, it was possible that a particular ward could be considered geographically remote from the main population centres, and still report a high population density. Their analysis revealed that suicide rates were generally higher in areas that were distant from the main urban centres, and that this trend was more evident when rurality was defined in terms of population potential rather than population density.

In addition to the influence of the economic climate, suicide rates have also been shown to vary according to political conditions. Shaw *et al.* (2002) demonstrated that the suicide rate across England and Wales was higher under the conservative government, and peaked at 135 per million under Ramsay McDonald, leader of the only coalition government in the 20th Century. On average, under a liberal government the suicide rate was 103 per million, while the average under Conservative power was 114 per million. The authors also calculated suicide rates for 1981-85, 1986-1990, 1991-98 and 1996-2000 at the Parliamentary Constituency level and associated these rates with the proportion of constituents that voted for the Conservative party during the 1983, 1987, 1992 and 1997 elections respectively. Their results showed that the negative correlations increased significantly over time under the Conservative government (–0.23, -0.34, -0.48 respectively, $p<0.05$), but weakened slightly under Labour (–0.47, $p<0.05$).

This brief introduction of the geography of suicide has demonstrated that since the seminal work of Durkheim in 1897, there have been many researchers interested in identifying social factors that lead a small proportion of the population to commit suicide. Many studies use similar variables, in combination or in isolation, and all come to the same conclusion: that there is no single ubiquitous hazard that acts as a trigger for suicide. However, those studies that investigated trends in suicide over time found that the fluctuations in the suicide rates paralleled variations in other social, economic, and/or political conditions.

Some research has suggested that suicides in Scotland have been increasing more in the Highlands and other rural parts of Scotland. For example, Crombie (1991) examined the spatial distribution of suicides among men in Scotland, having previously found no association between suicides and unemployment at the sub-national level (Crombie 1989). Using data from 1974-1986, Crombie explored the patterns in male suicides across the 56 Local Government Districts and reported a number of interesting findings. First, the eight Districts in the Highlands all had SMRs greater than 120. Second, there were only two Districts outwith the Highlands that reported SMRs above 124 – Edinburgh City and Wigtown (South West Scotland). Third, all but two Districts located within the central belt exhibited the lowest SMRs. Fourth, when the data were split into two time periods (1974-1979 and 1982-1986), Crombie reported that the spatial distribution was relative stability over time. For both periods, six of the Highland Districts had SMRs over 120, while nine Districts in the central belt that exhibited SMRs lower than 80.

Crombie suggested that the excessive number of suicides in the Highlands resulted from either a regional variation in mental illness or societal factors other than deprivation. However, Carstairs (1991) suggested that the high suicide rates reported by Crombie (1991) resulted from the significant number of non-residents committing suicides in the Highlands. There were 13 suicides from non-residents between 1986 and 1988, and the exclusion of these deaths produced a different result. The SMR for the Highland Health Board reduced from 136 to 119, just one percent higher than the borders (118), and only marginally higher than other Health Boards. The SMR for the Greater Glasgow Health Board was 111 while the Grampian Health Board had an SMR of 113. The data used in the present study were not affected by suicide among non-residents, as the mortality data were geo-coded to the deceased's postcode of usual residence, not the postcode of where the suicide event occurred.

McLoone (1996) examined the relationship between deprivation and suicide in Scotland and also showed that the suicide rate increased between 1981-1983 and 1991-1993 for young males and females but decreased for the older population. Moreover, the suicide rates were higher in deprived areas for each method used to complete suicides, except for suicide by car exhaust inhalation, which consequently exhibited the largest increase among the affluent areas. Self-poisonings and hangings showed the biggest increases in suicides within deprived areas, for example, the suicide rate for hangings in males aged 15 years and older increased from 6.7 per 100,000 in 1981-1983 to 10.7 per 100,000 in 1991-1993.

The author of this thesis and colleagues (Boyle *et al.* forthcoming) examined the widening suicide gap among the least deprived and most deprived areas in Scotland between 1980-1982 and 1999-2001. We found that deaths from suicide among the older population (aged 45 years and over) decreased during this period, while suicide among the younger adults (15-44 years), increased, particularly among younger males. Furthermore, while the mortality reduced among the older population decreased, the suicide gap widened for both age groups. For example, among younger adults, the suicide differential increased from 2.98 in 1980-1982 to 4.02 during 1999-2001, while relative inequalities among older adults increased from 1.51 in 1980-1982 to 1.81 in 1999-2001.

Stark *et al.* (2002) compared suicide rates in the Highlands with the rest of Scotland over twenty years (1978-1998), by age and sex, by the method of used, and occupation. They found that throughout the period, the rates for the Highlands were consistently higher than the Scottish rates for all age groups between 15 and 84. Their research also found excessive numbers of suicides involving drowning, gas exhaust inhalation and firearms, although firearm-related suicides had declined over the study period. With regard to occupation, 'rural' occupations such as forestry, farming and crofting were identified as occupations with notable proportions of suicides, accounting for approximately 7% of suicides in the Highlands between 1991 and 1998.

The Constituency Profiles, (PHIS 2004) reported that the Aberdeen Central Constituency had the highest incidence of deliberate self-harm (parasuicide) admissions to accident and emergency hospitals, 74.8% higher than the Scottish average. In addition to Aberdeen central, the report named nine areas of high incidence of deliberate self-harm (Dundee West, Glasgow Shettleston, Dundee East, Glasgow Anniesland, Cunninghame South, Glasgow Maryhill, Paisley North, Kilmarnock and Loudoun, Glasgow Springburn), which were all located outwith the Highlands. Of the seven Parliamentary Constituencies located in the Highlands and Islands, only one Constituency (Argyll & Bute) reported deliberate self-harm admission rates higher than the Scottish average. Moreover, the admission rate for Argyll & Bute was 17.6% above average, considerably lower than Springburn (43.9% above average), which had the tenth highest admission rate. The remaining

Constituencies were between 11.8% (Shetland) and 62% (Caithness, Sutherland and Easter Ross) lower than the Scottish average.

7.3.2. Suicide Prevention: Measures and Policies

One approach to reducing the suicide rate is to restrict accessibility to resources commonly used to commit suicide. For example, lower suicide rates have been associated with the transition from coal-based to natural gas (Kreitman 1976); the reduction in the prescribing of barbiturates (Johns 1977); the introduction of catalytic converters (Kendell 1998); appropriate reporting suicide in the media (Gunnell and Frankel 1994) and the geographic variation in access to firearms (e.g. Kaplan and Geling 1999).

Despite accounting for a relatively small proportion of all deaths per annum, suicide is the third most important contributor to years of life lost in the UK because so many suicide victims are younger (Gunnell and Frankel 1994). In the UK, a number of suicide prevention policies have been established, and a reduction of suicide is considered a key health target in England and Wales (Department of Health 2002) and Scotland (The Scottish Office 1999a). In Scotland, the national suicide prevention strategy and action plan, *Choose Life*, (The Scottish Executive 2002b) focuses on reducing the suicide rate by 20% between 2003 and 2013.

The framework for suicide prevention in Scotland operates at two scales (national and local), involving each department within the Scottish Executive, national agencies such as the Scottish Prison Service and JobCentre Plus, local agencies (e.g. NHS boards, social inclusion partnerships (SIPs), education authorities, children and family services), voluntary organisations (Samaritans, mental health organisations, Childline), researchers, and individuals. At the national level, the Scottish Executive will be responsible for the implementation and monitoring of the framework, and will ensure that the seven main objectives of the programme (Table 7-2) are met. Thus, the planning and implementation of suicide prevention schemes at the local level will be the responsibility of community based action groups, which will be given guidance by central and local agencies to ensure that the goals outlined in the *Choose Life* Report will be met.

Objective	*Aim*
Early Prevention and Intervention	To provide appropriate support to at risk populations and reduce the risks of suicidal behaviour
Responding to Immediate Crisis	To provide support to individuals at risk or in crisis, to ensure these individuals are provided with appropriate services and reduce severity of risk
Longer Term Work	On going work that enables individuals at risk to recover from, and deal with problems associated with, suicidal behaviour
Coping with Suicidal Behaviour and Completed Suicide	To provide support to individuals that have been affected by suicidal behaviour
Promoting Public Awareness	To increase public awareness of positive mental health and well being, and to raise awareness of the risks of suicidal behaviour and the services available to reduce such risks
Supporting the Media	To encourage the sensitive reporting of completed suicide and suicidal behaviour in the media.
Knowing What Works	To improve the quality, collection, availability and dissemination of issues relating to suicide

Table 7-2 The objectives of the Scottish suicide prevention strategy (Source: The Scottish Executive 2002b, p.21)

While the seven objectives outlined in Table 7-2 were designed to reduce the suicide rate across the entire Scottish population, the Scottish Executive acknowledged that some groups were more at risk than others, and therefore specified a number of priority areas upon which particular attention should be given. The priority groups included: children and young people, especially those children in care and young males; individuals that have mental health problems; individuals that have attempted suicide previously or those affected by suicide and suicide attempts; individuals in prison; and those individuals that have a history of substance abuse. In addition, particular attention and support has been suggested for individuals that have been recently bereaved, have suffered long-term unemployment, live in remote rural or isolated environments, or individuals that are homeless.

The suicide prevention strategy for Scotland has therefore been well researched and guided by the literature, identifying many of the key risks and vulnerable populations. However, the *Choose Life* could be criticised for only defining one priority theme that was explicitly geographic in nature (isolated or rural areas). Nonetheless, there is an implicit recognition for individuals experiencing socio-economic deprivation, which has been shown to be associated with an elevated risk of unemployment (Curtis *et al.* 2004), substance abuse (Koppel and McGuffin 1999) and mental health (Koppel and McGuffin 1999, Drukker and van Os 2003). However, the complex interaction between poverty-related factors is often concentrated within large cities (Pacione 2004).

Pacione (2004) examined the persistence of social deprivation in Glasgow City between 1971 and 2001 at the Enumeration District (1971-1981) and Output Area (1991-2001) level, using data derived from each decennial census. He mapped the locations (centroids) of the most disadvantaged 1% and 5% of census EDs/OAs for each census. The analysis showed that while some of the most deprived locations in 1971 had improved by 1981, 1991 or 2001, largely as a result of urban regeneration programmes and the subsequent clearance of tenement housing in the city centre, the deprivation in the majority of the 1971 centres had worsened over time and remained in 2001. While Pacione (2004) acknowledged the importance of the modifiable areal unit problem (Openshaw 1984), he failed to recognise that over the past 30 years significant changes were made to the composition of the census boundaries, and he was therefore not making consistent comparisons through time. Nonetheless, if deprivation is so closely associated with many of the risk factors known to elevate suicidal behaviour, then it must be contended that an explicit focus on deprived communities should have also been included in the key priority groups of the *Choose Life* report.

7.3.3. Summary

In summary, elevated suicide risk has been associated with a number of social, geographical, political and personal factors. In addition, there is evidence to suggest that the occurrence of suicide appears to cluster spatially, although this notion has typically been proven using anecdotal or aspatial analytical techniques. In Scotland, suicide has been associated with unemployment, deprivation, and mental illness. Furthermore, the suicide gap between the least and most deprived areas widened between 1981 and 1991 (McLoone 1996) and widened further between 1981 and 2001 (Boyle *et al.* forthcoming). The Scottish Executive is committed to reducing the suicide rate by 20% between 2003 and 2013 and has identified a number of priority groups, only one of which was explicitly geographical – individuals living in rural and isolated areas.

The remainder of this chapter builds on the findings regarding suicides reported in Chapter Five, by first examining the widening gap for males, females and all persons aged 15-44 and 45 years and older separately to determine whether the mortality gap varies with age over time. In England and Wales, suicide among younger adults has increased over the past 50 years, but has decreased among older adults. This analysis will determine whether similar patterns in suicide have been experienced in Scotland.

Second, the relationship between suicides and rurality is assessed, for the same age groups. In this analysis, the CATTs are aggregated into four areas: Highlands and Islands, Glasgow, Other Cities and All Other Areas. This analysis aims to clarify if the suicide rate is indeed higher in the Highlands and Islands than in Glasgow, thus assessing whether the *Choose Life* strategy was correct in only defining rural areas as a priority group for the reduction of suicide.

Third, the notion of suicide clusters is examined. Whereas clusters have been typically identified anecdotally or using aspatial techniques, in this analysis suicide among younger adults (15-44) will be identified using space-time cluster analysis. Unlike in previous Chapters in which the CATTs have been aggregated by deprivation quintile and/or area type, the cluster analysis will be conducted at the

CATT2 level.

The final piece of analysis in this chapter revisits the question of whether the Highlands exhibit a greater susceptibility to suicide than Glasgow. In this analysis, social data from the 1981, 1991 and 2001 censuses are aggregated to the CATT2 level and are used to explain the occurrence of suicide among young adults.

7.4. Deprivation and the Widening Suicide Gap

The widening suicide gap between 1980-1982 ('1981') and 1999-2001 ('2001') was calculated for all persons, males and females, for three age groups (all ages, 15-44, and 45+) and are reported in Table 7-3. In these analyses, period-specific quintiles were used, and the Standardised Mortality Ratios (SMRs) for 2001 were based on the 1981 death rates (i.e. 2001_{81} in Chapter Five). Note that the results for all deaths in Table 7-3 differ from those reported in Chapter Five, because the results in Chapter Five were not based on the 2001_{81} death rates. Rather, the approach used in Table 7-3 is akin to the approach typically used in the existing literature.

Table 7-3 shows that in 1981, the suicide inequalities between the least deprived the most deprived were higher for males, in all three age groups considered. The inequalities were highest for younger males, for which suicides were 2.99 times higher in the most deprived CATTs than the least deprived CATTs. While there were substantial differences between the inequalities reported for males and females (separately and combined) for all ages, the differences between inequalities for males, females and all persons were very similar for the 15-44 and older age groups. For example, the suicide inequalities recorded for young people (15-44) were widest for males (2.99), followed by all persons (2.98) and females (2.96). Although inequalities between the least and most deprived CATT2s were considerably lower among the older ages, the gap between older males and older females was wider among than for the younger group. Suicides were 1.66 times more prevalent in most deprived than in least deprived areas for older males, followed by 1.51 for all older persons, and 1.33 for older females.

	1981 Ratio Quintile5:Quintile 1	*2001$_{81}$ Ratio Quintile5:Quintile 1*	*Absolute Change*	*Ratio Change*
All Deaths				
All Persons	2.03	3.00	0.97	1.48
Male	2.23	2.91	0.68	1.30
Female	1.73	3.32	1.59	1.92
15-44				
All Persons	2.98	4.02	1.04	1.35
Male	2.99	3.67	0.68	1.23
Female	2.96	5.77	2.81	1.95
45+				
All Persons	1.51	1.81	0.31	1.21
Male	1.66	1.88	0.22	1.13
Female	1.33	1.70	0.37	1.28

Table 7-3. The widening suicide gap (1981-2001), by age and sex

Female suicides reduced by 19.58%, from 802 in 1981 to 645 in 2001, while male suicides increased by 40% from 1,367 in 1981 to 1,918 in 2001. However, Table 7-3 shows that the inequalities in female suicides increased considerably for all age groups. Older women living in the most deprived areas in 2001 were 1.88 times more susceptible to dying from suicide than older women in the least deprived areas. In contrast, suicides were 5.77 times higher for younger women (15-44) in the most deprived areas than in the least deprived areas. The inequalities reported for males were not as large as they were for females in 2001, although they remained wide, ranging from 1.88 for the older population to 3.67 for the younger population. Thus, the suicide gap in 2001 was especially wide for young males and females, particularly the latter.

The third column in Table 7-3 recorded the absolute change observed in the inequalities between 1981 and 2001, where a positive value indicates that suicide inequalities have widened over time. Not surprisingly, females exhibit the highest absolute increases in inequalities across all ages and for the younger age group. Inequalities among older women worsened the least, increasing by 0.37 between 1981 and 2001. Among males, inequalities among all persons and the 15-44 age group experienced an absolute increase of 0.68 each, while suicide among the older age group increased by 0.22 in absolute terms. The final column in Table 7-3 represents the relative increases in inequalities over time, and shows that the differential between the least and most deprived quintiles widened for all age groups, for males and females (separately and combined). Relative inequalities widened least among older males (1.13) but widened most for younger females (1.95). Note that while the absolute change in inequalities among younger males was the same as for all males, the relative increases in inequalities were different. Relative inequalities among younger males were 1.23 times greater than in 1981, while the suicide differential for all males was 1.30.

Figure 7-2 shows the social gradients in suicide mortality for 1981-2001 for all persons, males and females, and for the three age groups studied. It shows a clear linear pattern existed for each age group, gender and year observed, demonstrating a stepwise increase from quintile 1 through to quintile 5. The gradients shown in Figure 7-2 complement the results reported in Table 7-3, but elucidate the variation of inequalities between each age group and gender studied. In particular, for all persons at all ages, Figure 7-2a illustrates the increase in suicide between 1981 and 2001 in quintile 4 and quintile 5 and, more importantly, that the increase in the SMR in deprived areas was significantly higher than in 1981. As Table 7-3 suggested, Figure 7-2b shows that the suicide rate for all older persons decreased, while suicides increased for all younger persons (Figure 7-2c). However, the inequalities reported in Table 7-3 failed to show that the reductions in suicides were significantly lower in 2001 than in 1981 for quintile 4 and quintile 5 among the older population while among the younger population, these two quintiles also experienced significant increases over time.

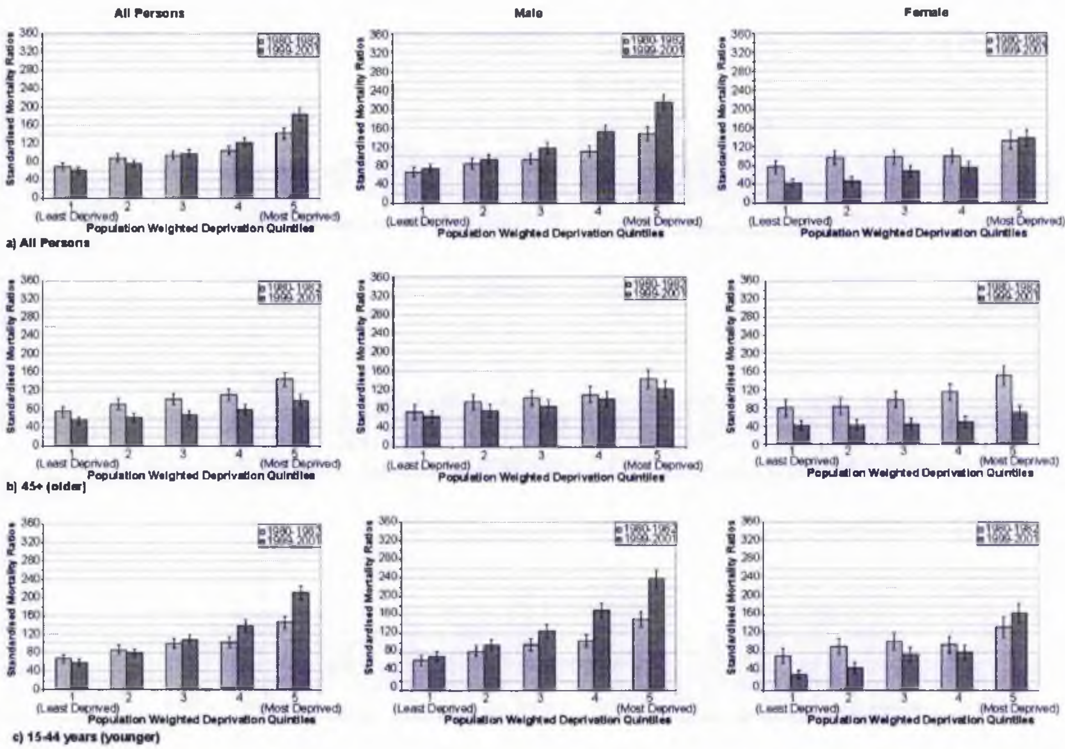

Figure 7-2 Age-sex standardised mortality ratios for suicides 1981-2001

The second column of graphs in Figure 7-2 represents the changing social gradient for males for different age groups. In the main, the trends for males emulated the patterns for all persons, particularly for older age mortality although the relative improvement for older males in quintile 5 (between 1981 and 2001) was not as great as for all older persons. A notable difference between the gradients for all persons and all males (Figure 7-2a) was that in contrast to the trend for all persons, which experienced reductions in suicide rates for quintiles 1 and 2 between 1981 and 2001, SMRs for males increased across each quintile in 2001. Furthermore, the suicide rates for males in quintile 4 and 5 were significantly higher than their respective 1981 SMRs. The increase in suicide among the quintiles for all males in 2001 was replicated for younger males (Figure 7-2c), whereby significant increases were observed for quintiles 3, 4 and 5 in 2001. Although inequalities did not widen as much for males as they did for females, Figure 7-2 indicates that the suicide rate increased significantly in the most deprived quintiles. Furthermore, the relative improvement in the less deprived quintiles was not as substantial for males as it was for females, which also helped constrain the increase in inequalities among males.

Although the number of females committing suicide decreased over time, inequalities persisted, particularly for the younger age groups. In contrast to all persons and all males, suicides among all females only increased in the most deprived quintile (column 3, Figure 7-2a), while significant reductions in quintile 1 and quintile 2 were reported for 2001. Suicide among older females (Figure 7-2b) reduced significantly for each quintile in 2001, while among younger females (Figure 7-2c), such improvements were only found for the less deprived quintiles (1 and 2). Moreover, suicide among younger females only increased for the most deprived quintile

7.5. An Urban or Rural Problem?

Crombie (1991) and Stark *et al.* (2002) suggested that suicide rates in the Highlands are significantly higher than other parts of Scotland. This Section examines whether the suicide rates in the Highlands are indeed higher than in other parts of Scotland. For this analysis, the CATT2s were aggregated to approximate the 32 Scottish Council Areas for 2001, and then apportioned to four categories: 'Highlands and Islands ', 'Glasgow', 'Other Cities', and 'All Other Areas' (Figure 7-3). There were relatively few deaths in the Highland Council Area, so the adjacent Council Areas (Argyll & Bute, Orkney Islands, Shetland Islands, and Eilean Siar) were also allocated to the 'Highlands and Islands ' category. The 'Other Cities' category consists of CATTs that were located in Aberdeen, Dundee and Edinburgh, while the 'All Other Areas' grouping includes remote rural settlements as well as bigger towns such as Stirling, Inverness, and St Andrews.

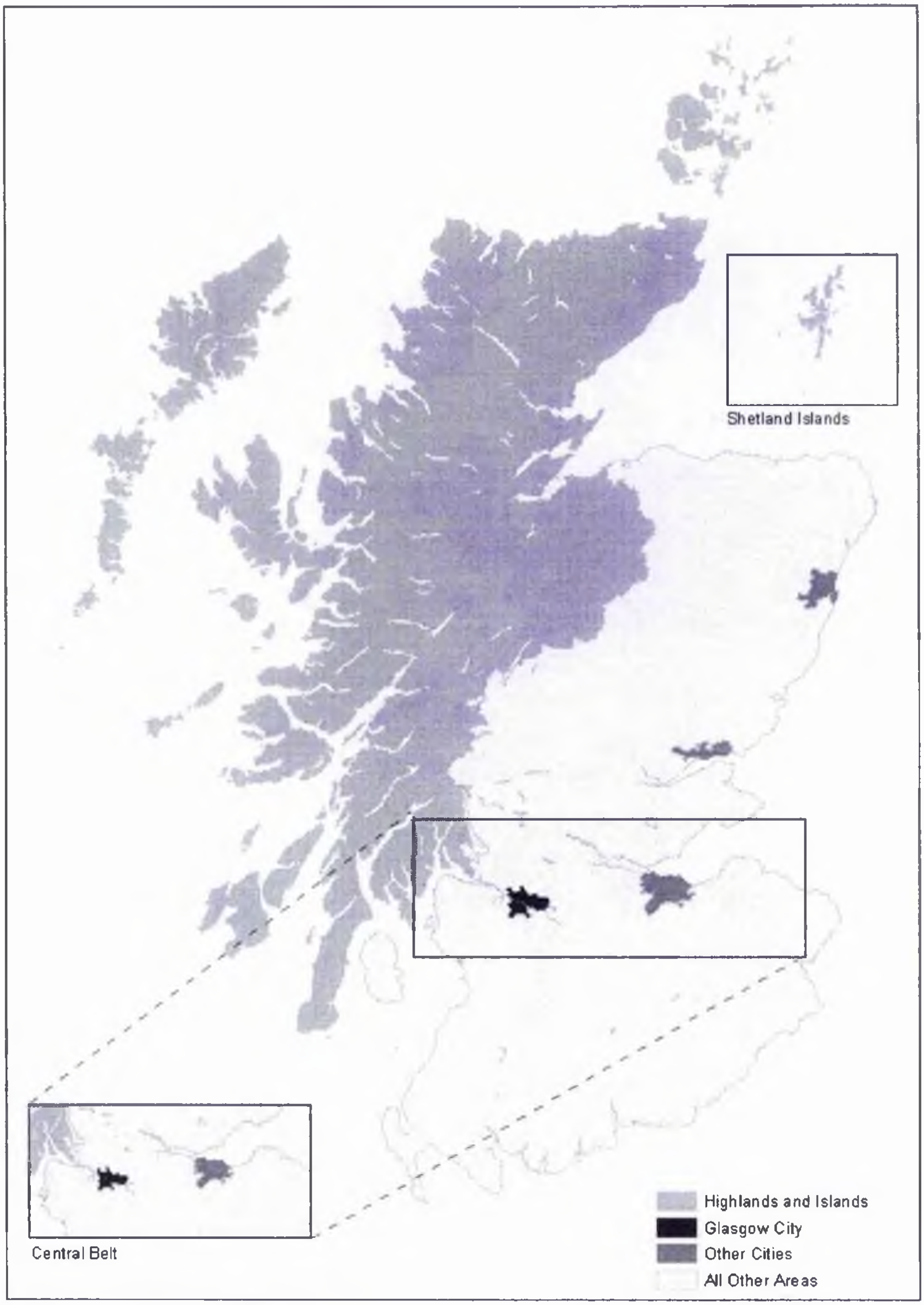

Figure 7-3 The allocation of CATT2s to the four area types used in the analysis of suicide

Table 7-4 shows that between 1981 and 2001, the number of suicides in Glasgow decreased slightly, while increases were experienced for each Other Cities/rural category. Similarly, the population declined substantially in Glasgow, while considerable increases were observed in the Highlands, and the two 'Other' categories. In Chapter Six, it was shown that places that had declined over time also exhibited the highest mortality ratios, although adjusting for the deprivation of these areas cancelled the effect of population change. Therefore, it might be expected that the suicide rates in Glasgow would be higher than those in the Highlands.

Area Type	*Population*		*Suicides (All Ages)*	
	1981	2001	1981	2001
Glasgow	679,172	571,543	451	425
'Highlands'	342,187	368,019	168	215
Other Cities	792,999	816,548	373	431
All Other Areas	3,197,910	3,305,837	1,177	1,492
Total[5]	5,012,268	5,061,947	2,169	2,563

Table 7-4. The population and suicide distributions for 1981 and 2001 in the four 'urban/rural' groups

Age and sex standardised mortality ratios were calculated for 1981 and 2001, for all ages and for the younger (15-44) and older (45+) populations in the four area types, using period specific quintiles and the 1981 standard population, and are shown in Figure 7-4. For all young persons the suicide rate for 2001 was significantly higher than in 1981. Furthermore, the 2001 suicide rate for all young persons was significantly higher in Glasgow than in the other three areas studied. However, while Glasgow had the highest mortality rate, the greatest relative increase among all young people was for the 'All Other Areas' category (1.63). Surprisingly, Glasgow reported the smallest relative growth in suicide among younger people (1.47), although one should bear in mind that the suicide rate in Glasgow was very high to start with and we should therefore interpret these results with care.

It can be seen from Figure 7-4 that the suicide rates also increased for young males and females, but only significantly for males, in all four areas between 1981 and 2001. In absolute terms, the increase was greatest for young males in Glasgow, where the SMR for suicides increased from 161.81 to 268.24 in 2001 – an increase of 96.43. Figure 7-4 also shows that the 'Other Cities' group demonstrated the smallest absolute increase in mortality (57.55), increasing from 106.22 to 163.77

[5] Note that one CATT located in Glasgow was omitted in the construction of the Carstairs index, so the population is slightly lower than the totals reported in each census

among young males. With a relative increase in mortality of 1.66, the Highlands, where the suicide rate for young males increased from 126.66 to 209.73, showed a greater increase than younger males in Glasgow (1.60). However, the 'All Other Areas' group demonstrated the largest relative increase for young males (1.86), from 83.05 to 154.36.

Suicide among young females was also higher in 2001 than in 1981 but none of the increases were statistically significant. The relative changes in young female suicides differed to those exhibited by males. First, the scale of the increases was not as great for females, ranging from 1.04 in Glasgow to 1.51 in Other Cities. Second, the ranking of the increases varied between males and females. For young females the largest relative increase occurred in the 'Other Cities' category, for which the suicide rate was 1.51 times higher in 2001 than in 1981. The Highlands and Islands experienced the next biggest increase, with a relative increase of 1.17. Whereas the 'All Other Areas' category showed the biggest increases for males, the growth in this group of areas was much more moderate for young females (1.12). In absolute terms, the increase in suicides rate among young females was smallest in the Highlands and Islands (2.81) compared to a 29.66 absolute increase in Glasgow and a substantial absolute increase of 49.22 in the Other Cities.

Significant reductions in suicide among older people between 1981 and 2001 were observed in each area except in the Highlands, which declined but not significantly (Figure 7-4). In relative terms, suicide among older adults in Glasgow and Other Cities reduced the most (0.67), while the relative reduction in suicide for the 'All Other Areas' areas (0.76) was marginally better than the reduction in suicide reported for the Highlands and Islands (0.78). However, in absolute terms, the suicide rate for older people improved most in Glasgow, reducing by 46.19 from 141.54 in 1981 to 95.36 in 2001. Other Cities showed the second largest reduction (35.31) while the suicide rate for all older adults in the Highlands and Islands reduced by 24.98, from 114.56 in 1981 to 89.58 in 2001.

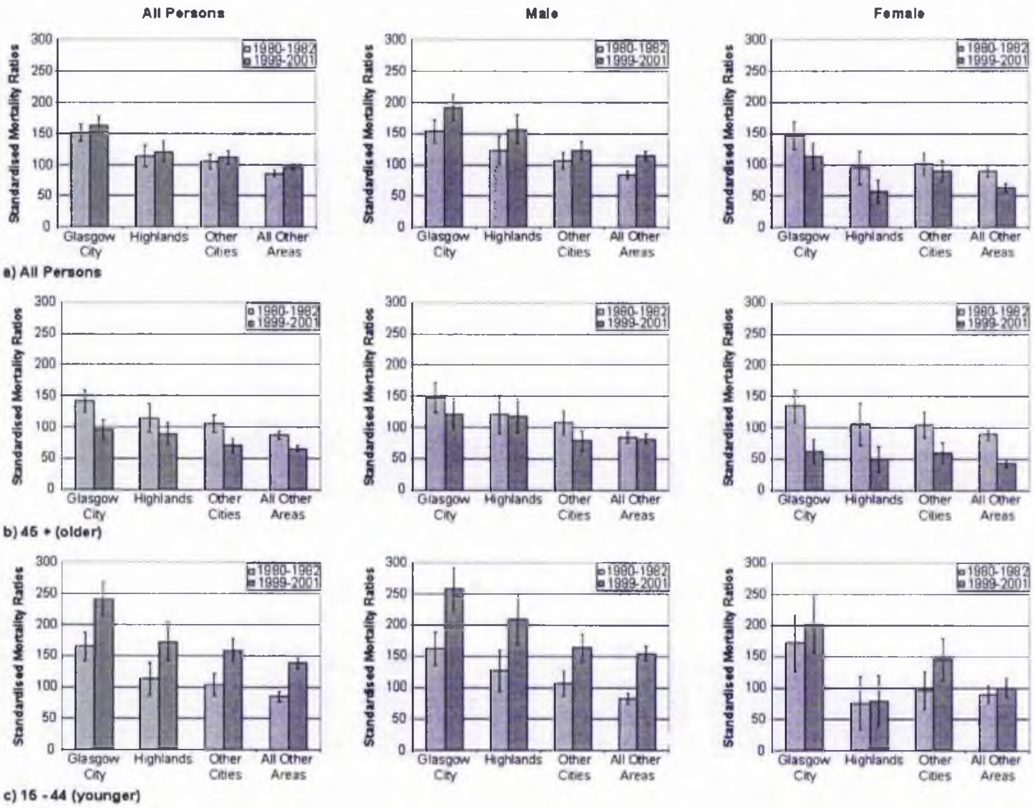

Figure 7-4 Suicide SMRs for different age and sex groups, 1981 and 2001

The reductions in suicide mortality were much lower for older males than for older females. However, there were no significant reductions observed for older males, but the reductions for females were significantly lower in 2001 than 1981 all four areas. For older males, the 'All Other Areas' group decreased the least in absolute terms, by 2.15 from 84.65 in 1981 to 82.50 in 2001. The Highlands and Islands also demonstrated a modest absolute reduction for males (3.18), decreasing from 121.45 in 1981 to 118.27 in 2001. Glasgow and 'All Other Areas' areas both experienced considerable (but not statistically significant) declines among older men, from 147.24 to 121.28 (25.96), and 107.84 to 78.73 (29.11) respectively. In relative terms, The Highlands and Islands and the 'All Other Areas' category showed only marginal relative changes for older males, each reporting a three percent reduction between 1981 and 2001. The suicide rate for older men in Glasgow was 18% lower in 2001 than in 1981, but the Other Cities category showed the most substantial reduction among older men, declining by 27% over the twenty-year period.

Suicide rates among the older female population reduced most in Glasgow in absolute terms, by 72.50 from 134.42 in 1981 to 61.92 in 2001. Similarly, suicides for older females in the Highlands and Islands also showed impressive improvements, decreasing from 105.06 to 49.43 – an absolute reduction of 55.63. The Other Cities category exhibited the smallest absolute reduction for older females (44.30), reducing from 104.10 in 1981 to 59.80 in 2001. Although the range of absolute improvements in the suicide rates for older females varied considerably, the relative changes over time were more similar. For example, the relative ratio for older females in Glasgow was 0.46, followed closely by the Highlands and Islands (0.47) and 'All Other Areas' (0.48).

This analysis confirms the findings of others (e.g. Gunnell *et al.* 2003; Dorling and Gunnell 2003): that the suicide rates are increasing for the younger population and decreasing for the older population. However, this analysis has not found that the suicide rates in the Highlands and Islands were the highest in Scotland, as suggested by Crombie (1991). Rather, for each age group, gender, and time period, the highest suicide rates were found in Glasgow. Furthermore, the results presented in this Section have suggested that suicides continue to be more prevalent in urban, rather than rural areas, especially for young males.

7.5.1. The role of deprivation in explaining the differences

One problem in the previous analysis was that the four area categories covered very large parts of Scotland, and it was assumed that these areas were essentially homogeneous. However, within each of the four areas the prevalence of suicides will vary by deprivation. Because the occurrence of suicide is relatively rare, the data from quintiles 1, 2 and 3 have been grouped together to form a 'low deprivation' category and quintiles 4 and 5 have been grouped to create a 'high deprivation' category. SMRs were calculated for males, females and all persons in 1981 and 2001, for the four areas used in the previous Section, and by the low/high deprivation classification. Again, the period specific quintiles were used to define deprivation, and the 1981 death rates were applied to the 2001 data to identify relative changes in the suicide rates over time.

Figure 7-5 shows suicide SMRs for three age groups (all ages, 15-44 and 45+) and three gender classifications (all persons, males and females), by deprivation category. In the main, the expected trends were observed for each age group and sex, with the high deprivation category experiencing higher rates than the low deprivation category, while suicides increased for younger adults and decreased among older people. The first column of Figure 7-5 shows suicide trends for males and females combined across all ages, 15-44 (younger) and 45+ (older). Although the suicide rates were significantly higher in high deprivation areas than in low deprivation areas of Glasgow in 1981 and 2001, as well as in the 'Other Cities' and 'All Other Areas' groups for 2001 across all ages, the occurrence of suicide in high deprivation areas in the Highlands were not significantly higher than in low deprivation areas of the Highlands. Glasgow reported the highest suicide ratios in deprived areas for 1981 and 2001 across all ages but the SMRs were not significantly higher than the Highlands and Islands or the Other Cities category.

Among all young people, the suicide rate was significantly higher in deprived areas of Glasgow and the 'All Other Areas' in 1981. By 2001, the SMRs for suicides occurring in areas of high deprivation were significantly higher than in low deprivation areas – for each of the four area categories examined. The most deprived category in Glasgow had the highest suicide rate in 1981 and 2001, but this was only significantly higher than Other Cities and All Other Areas in 1981, and in All Other Areas in 2001. Figure 7-5 also shows that suicides increased significantly within areas between 1981 and 2001. The SMRs for suicides in the high deprivation category in Glasgow increased from 197.49 in 1981 to 289.41 in 2001. Significant increases were observed in the high deprivation categories of the Other Cities, rising from 121.57 1981 to 256.17 in 2001, while the rate of suicides in 'All Other Areas', areas of high deprivation increased from 109.27 in 1981 to 208.14 by 2001. Only the low deprivation category in 'All Other Areas' demonstrated significant increases in suicide among all younger people.

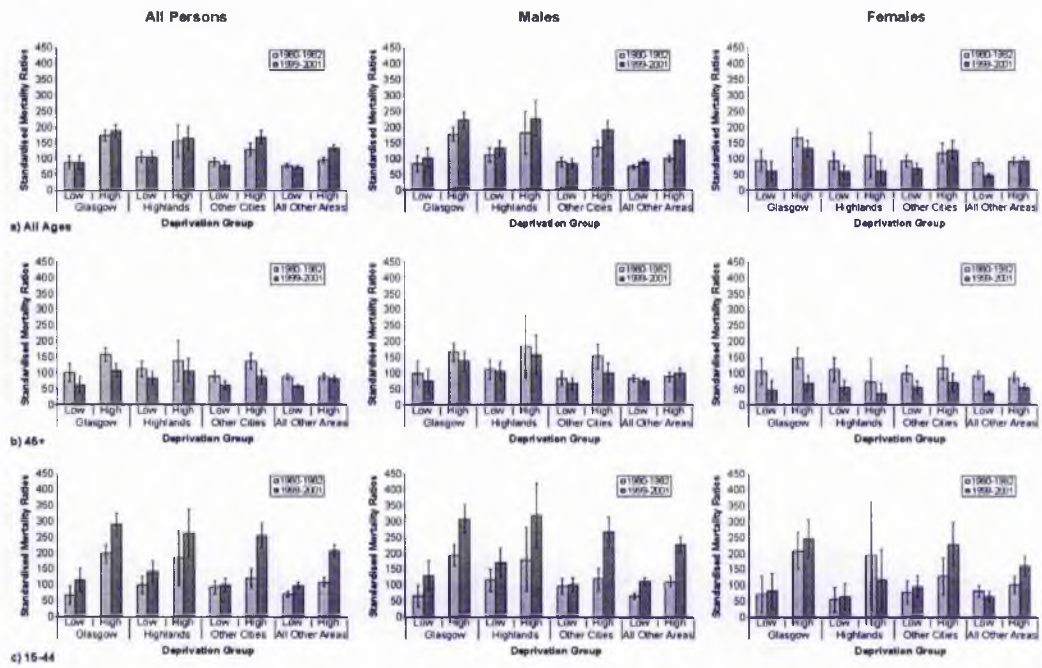

Figure 7-5 SMRs by deprivation group and area classification, 1981 and 2001

In contrast, there were fewer significant changes in suicides among all older adults. Within Glasgow, suicide rates were significantly higher in the areas of high deprivation category than in areas of low deprivation in 1981 and 2001. Furthermore, although the suicide rate decreased among older people between 1981 and 2001, the reduction was only significant for the high deprivation category. Within Other Cities, suicide rates were also significantly higher for the areas of high deprivation than for the low deprivation category in 1981. A significant decline in suicides was found in low deprivation parts of 'All Other Areas', from 86.99 in 1981 to 57.81 in 2001. Suicide in the Highlands and Islands among all older persons was more prevalent in high deprivation than in low deprivation areas in 1981 and 2001, and although the suicide rate decreased in high and low deprivation categories in the Highlands, none of these trends were significant.

Suicide trends for males are shown in the second column of Figure 7-5, indicating significantly higher suicide rates among all males in the high deprivation category than the low deprivation category in all areas except the Highlands and Islands in 1981, and all four areas in 2001. It should be noted that the suicide rates among all males were marginally higher in the Highlands and Islands than in Glasgow during both time periods for the high and low deprivation categories. In 1981 low deprivation areas in the Highlands and Islands had an SMR of 113.05, compared with 84.10 in low deprivation areas of Glasgow, while in 2001 the values were 133.13 in the Highlands and Islands and 104.45 in Glasgow. High deprivation parts of the Highlands and Islands reported an SMR of 182.19 in 1981, compared with 178.54 in Glasgow, increasing to 228.27 in the Highlands and Islands and 223.84 in Glasgow for 2001. However, Figure 7-5 also shows that the higher SMRs reported for the Highlands and Islands among all males were not significantly different to the rates in Glasgow.

The trends for younger males were similar to those for all younger persons (Figure 7-5), in which the high deprivation category had significantly higher SMRs than the low deprivation category in each of the four area classifications for 2001. However, in 1981 rates in the high deprivation category were only significantly higher than the low deprivation category in Glasgow and the 'All Other Areas' category. While the trends were very similar for all younger persons and younger males (15-44), the SMRs were typically larger for males. For example, in 2001, the SMRs for the low and high deprivation categories for all younger persons in Glasgow were 115.96 and 289.41 respectively, while the 2001 SMRs for younger males were 130.40 in the low deprivation category and 308.35 in the high deprivation group. The SMRs for younger males increased significantly within the high deprivation category between 1981 and 2001 in Glasgow, Other Cities and All Other Areas, while significant increases within the low deprivation category were only observed in 'All Other Areas'. The difference in the SMRs between Glasgow and the Highlands and Islands for younger males was not statistically significant, yet some interesting comparisons could be made. Of the two localities, Glasgow had the lowest SMR for the low deprivation category in both time periods, and the highest SMR for the high deprivation category in 1981. By 2001, however, the Highlands and Islands had the higher suicide rate among the high deprivation group.

Figure 7-5 demonstrates an inconsistent trend for older males, in which the high deprivation category was significantly higher than the low deprivation category in Other Cities in 1981, and the 'All Other Areas' group in 2001. The majority of high and low deprivation groups demonstrated reasonable reductions in suicide rates over time but none of the reductions were significant. In the Highlands, the low deprivation category demonstrated an absolute reduction of 4.44 from 109.95 in 1981 to 105.51 in 2001, while the high deprivation category in the 'All Other Areas' group was the only category to increase over time in this age-sex group, from 88.31 in 1981 to 101.05 in 2001.

The final column of Figure 7-5 relates to the trends in female suicide between 1981 and 2001. Among all ages, the suicide rate in the high deprivation category was only significantly higher than the low deprivation category in Glasgow, while in 2001 significant differences between the high and low deprivation categories were found in Glasgow, Other Cities and the 'All Other Areas' group. Whereas all males experienced an increase in suicide rates between 1981 and 2001 in both deprivation categories across all four areas, the suicide rates for all females decreased over time in all cases except for the high deprivation category in Other Cities and the 'All Other Areas' areas. Of the observed reductions over time, only the low deprivation category in 'All Other Areas' areas was significant, whereby suicides among all females fell from 89.07 in 1981 to 46.08 in 2001.

The patterns for younger (15-44) female suicides shown in Figure 7-5 were similar to those found for all younger persons and younger males. In particular, the suicide rate was significantly higher in high deprivation areas than in low deprivation areas in Glasgow in 1981, and in Glasgow, Other Cities and Other areas in 2001. Two notable differences between the younger males and younger females were apparent in Figure 7-5. The first was the absence of a significant difference between the high and low deprivation categories in the Highlands and Islands for younger females, which was the case for younger males. The second difference was a relatively small SMR, and a subsequent (though not significant) reduction, in 2001 among younger females in the high deprivation category of the Highlands. Among younger females, the only significant increase between 1981 and 2001 within the same category was demonstrated by the high deprivation category in 'All Other Areas', where suicides increased from 102.10 in 1981 to 161.05 in 2001. Conversely, significant reductions over time were reported among older females for the high deprivation category in Glasgow, and Other Cities, while significant increases in younger male suicide were reported for the high and low deprivation categories in All Other Areas. In Glasgow, the high deprivation category reported a reduction in suicide for older females, from 147.09 in 1981 to 67.43 in 2001. Similarly, the low deprivation category in the 'All Other Areas' areas fell from 92.45 in 1981 to 37.08 in 2001.

To summarise, Figure 7-5 shows that the occurrence of suicide in 1981 and 2001 was consistently greater in high deprivation areas than in low deprivation areas, regardless of the age group or gender of interest. However, the difference between the SMRs for these two categories was not significant for all areas, with the Highlands and Islands only reporting significant differences for all younger persons in 1981. In contrast, suicide rates for the high deprivation category in Glasgow were significantly higher than in low deprivation parts of Glasgow for all age groups and all time periods. The trends for Other Cities and All Other Areas were also inconsistent, with only a small proportion of the age-sex groups demonstrating significant patterns. Glasgow also featured regularly in the discussion of significant differences within the same category. For example, significant increases were found in the deprived category between 1981 and 2001 among young males, while significant decreases in the SMR for suicide among older women decreased significantly over time in Glasgow.

One surprising result from Figure 7-5 was the notable absence of significant changes in suicide trends in the Highlands. The relatively large confidence intervals found in each of the graphs for the Highlands and Islands in Figure 7-5 resulted from the comparatively small population and a small number of reported suicide events. There were 368,019 people resident in the Highlands and Islands in 2001 and just 215 reported suicides (Table 7-4), compared with over 3 million residents and 1,492 suicides in 'All Other Areas' in 2001.

7.5.2. The Widening Suicide Gap by Geographical Area

The widening suicide gap in urban and rural areas was also assessed by calculating the ratio of inequalities between the low and high deprivation categories, by age group (all ages, 15-44 and 45+), sex, and area (Table 7-5). In addition, the absolute and ratio (relative) changes in suicide inequalities have also been provided. When suicides across all ages were considered, Glasgow had the largest mortality gap for all persons, males and females in 1981 and for all persons and females in 2001. Males experienced the largest inequalities within Glasgow in 1981, where the suicide rate was 2.12 times greater in high deprivation than in low deprivation areas. However in 2001, inequalities among all females in Glasgow had made an absolute increase of 0.48, increasing from 1.75 in 1981 to 2.23. In contrast, the suicide differentials were smallest among the 'All Other Areas' category in 1981 and the Highlands and Islands in 2001 - for males, females and all persons.

Because Glasgow showed the largest inequalities in suicides among all persons in 1981 and 2001, one might assume that the largest increases in inequalities between 1981 and 2001 might also have been experienced in Glasgow. However, Table 7-5 shows that this was not the case, with the Other Cities category demonstrating the largest absolute and relative increases over time. There was an absolute increase of 0.72 the suicide differential from 1.42 in 1981 to 2.14 in 2001 for Other Cities, which translated to a relative increase of 1.51. The Highlands and Islands experienced the smallest change in inequalities among all persons between 1981 and 2001, with an absolute increase of 0.09 from 1.48 in 1981 to 1.57 in 2001, and a subsequent relative increase of 1.06

Among all males, Table 7-5 shows that the inequalities between the least deprived and most deprived categories widened least for Glasgow and the Highlands, with absolute rises of 0.02 and 0.10 respectively. Although Glasgow and the Highlands and Islands both showed marginal relative increases in the suicide differentials over time, it should be noted that the inequalities in Glasgow were considerably higher than those in the Highlands and Islands in both periods, which was also demonstrated in Figure 7-5.

The 'All Other Areas' category experienced the largest absolute and relative growth in inequalities between 1981 and 2001 among all females. The suicide differential increased from 1.02 in 1981 to 2.03 in 2001, an absolute increase of 1.01 and a relative increase of 1.99, which was the most substantial increase reported for the analyses for suicide across all ages. Suicide inequalities decreased over time for females across all ages in the Highlands, reducing from 1.20 to 1.05, a relative decrease of 12% (i.e. ratio change of 0.88).

Among the younger and older populations, except for younger females in 1981, the inequalities in Glasgow were considerably higher than the inequalities found in the Highlands and Islands for both time periods. A further note of interest was that the inequalities among all persons aged between 15-44 in the Highlands and Islands did not change over time in relative terms. Table 7-5 also shows that for all younger persons and for younger males, there was a relative improvement in inequalities of 14% and 19% respectively in Glasgow. In contrast, inequalities increased marginally between 1981 and 2001 for young females, with a ratio change of 1.05. For younger females, the biggest improvement in suicide inequalities over time was observed in the Highlands, where the inequalities made a 48% reduction, with relative inequalities reducing from 3.50 in 1981 to 1.83 in 2001.

The Other Cities category exhibited considerable increases between 1981 and 2001, particularly for all younger persons and younger males, with relative increases of 1.95 and 2.17 respectively. For younger males, the inequalities in Other Cities had increased from 1.21 in 1981 to 2.63 in 2001. While relative inequalities for young females also increased by 1.45 in the Other Cities areas, the 'All Other Areas' category experienced the widest suicide gap for young women, at 2.03 times greater in 2001 than in 1981. The increase in the 'All Other Areas' category resulted from the prevalence of suicide reducing in the least deprived category from 82.90 in 1981 to 64.43 in 2001 and a considerable increase in the most deprived category from 102.10 in 1981 to 161.05 in 2001.

	All Persons				*15-44*				*45+*			
All Persons	*Low: High 1981*	*Low: High 2001*	*Absolute Change*	*Ratio Change*	*Low: High 1981*	*Low: High 2001*	*Absolute Change*	*Ratio Change*	*Low: High 1981*	*Low: High 2001*	*Absolute Change*	*Ratio Change*
Glasgow	1.97	2.15	0.18	1.09	2.90	2.50	-0.40	0.86	1.55	1.73	0.18	1.11
Highlands	1.48	1.57	0.09	1.06	1.85	1.84	-0.01	1.00	1.24	1.26	0.02	1.01
Other Cities	1.42	2.14	0.72	1.51	1.31	2.56	1.25	1.95	1.51	1.41	-0.10	0.94
Other Areas	1.21	1.82	0.61	1.50	1.53	2.11	0.59	1.38	1.00	1.40	0.40	1.40
Males												
Glasgow	2.12	2.14	0.02	1.01	2.91	2.36	-0.54	0.81	1.66	1.85	0.19	1.11
Highlands	1.61	1.71	0.10	1.06	1.56	1.86	0.30	1.19	1.66	1.50	-0.17	0.90
Other Cities	1.50	2.28	0.78	1.52	1.21	2.63	1.42	2.17	1.83	1.51	-0.33	0.82
Other Areas	1.35	1.77	0.42	1.31	1.67	2.03	0.36	1.22	1.07	1.38	0.32	1.30
Females												
Glasgow	1.75	2.23	0.48	1.27	2.88	3.03	0.15	1.05	1.42	1.48	0.07	1.05
Highlands	1.20	1.05	-0.15	0.88	3.50	1.83	-1.66	0.52	0.65	0.64	-0.02	0.97
Other Cities	1.29	1.85	0.56	1.43	1.63	2.37	0.74	1.45	1.18	1.26	0.08	1.07
Other Areas	1.02	2.03	1.01	1.99	1.23	2.50	1.27	2.03	0.93	1.49	0.56	1.61

Table 7-5 The suicide gap for the four urban/rural categories

Among the younger population, Glasgow shows a considerable improvement in the suicide differential for males, reducing (in absolute terms) by 0.54 from 2.91 in 1981 to 2.36 in 2001, and resulting in a relative improvement of 19%. For younger females in Glasgow, the suicide differentials increased by 0.15 in absolute terms from 2.88 in 1981 to 3.03 in 2001: a relative increase of 1.05. Inequalities among younger females in the Highlands and Islands halved between 1981 and 2001, reducing from 3.50 in 1981 to 1.83 in 2001.

The 'All Other Areas' category demonstrated considerable increases in suicide inequalities over time in the older age group (45+). For example, in 1981 for all older people, there was no relative suicide gap between the most and least deprived categories, as the SMR in the low deprivation group was 86.99 while the SMR in the high deprivation category was 87.26. By 2001 however, the suicide gap had widened to 1.40, which resulted from the low deprivation category decreasing to 57.81 and the deprived category reducing by only 6.07 to 81.19. Suicide inequalities for older males in the 'All Other Areas' area were slightly lower than for all older persons at 1.30, but widened the most for older females at 1.61. The SMR for suicides in the high deprivation category (85.91) in the 'All Other Areas' group was lower than for the low deprivation category (92.45) in 1981, but in 2001 the least deprived category had improved more (SMR=37.08) than the most deprived category (55.35).

Although the Other Cities showed the highest relative increases in suicide inequalities over time among younger people (all persons, males and females), the suicide gap reduced in these areas for older persons and older males. Thus, the ratio change in Other Cities was 0.94 for older persons and 0.82 for older males, while the inequalities among older females in these areas increased by 7% between 1981 and 2001. Similarly, the suicide gap had narrowed for all younger persons and younger men in Glasgow, but the suicide differentials for older persons and older males in Glasgow widened over time, each reporting a ratio change of 1.11. Moreover, Table 7-5 shows that although the absolute change in inequalities among younger females in Glasgow was twice as high as that reported for older females (in Glasgow), the relative inequalities had widened by the same amount (1.05) in both age groups.

This Section has shown that although the inequalities between the low and high deprivation categories were considerably higher in Glasgow than the other three areas, the suicide gap did not widen substantially over time. Rather, for all young persons and young males, the suicide gap decreased by 14% and 18% respectively, and the biggest increase in suicide inequalities for Glasgow was 1.11 each for older persons and older men. In contrast, the suicide gap in the Highlands and Islands increased most for young men, with a relative growth of 1.19 over time. For the other gender and age groups, the Highlands and Islands showed fractional increases or substantial decreases in the suicide gap between 1981 and 2001. Although Figure 7-5 showed that suicide rates were consistently larger in deprived parts of Glasgow than in other areas, Table 7-5 indicated that inequalities widened the most in the Other Cities category, which comprised Aberdeen, Dundee and Edinburgh, especially for all persons and males in all three age groups.

One of the problems associated with adopting the ratio change measure to quantify the widening suicide gap is that the method hides the fact that for 1981 and 2001 the suicide inequalities in Glasgow were considerably higher than those experienced in the Highlands. For example, among younger males, the gap reduced by 19% in Glasgow, while the gap widened by 19% in the Highlands. Yet in 2001, the suicide gap among young men between the low and high deprivation categories in Glasgow was 2.36, some 27% higher than the inequalities in the Highlands and Islands (1.86). Therefore the results in Table 7-5 have indicated that deprivation does not fully explain the suicide gap between the Highlands and Islands and Glasgow.

7.6. Clusters of Suicide

While the quintile-based analyses have been useful in identifying inequalities between the more and less deprived areas in Scotland, the methods used could have been implemented using any geographical scale, provided that boundary changes were accounted for. Furthermore, the quintile-based analyses do not (explicitly) identify small areas that require special attention in order to help reduce inequalities, but were used because the number of deaths in each CATT was too small to calculate reliable SMRs. However, it is possible to use alternative approaches to examine mortality at the CATT level, and thus identify localities that may require policy interventions to help improve the health of the local population.

The following two Sections investigate suicides at the local scale, in which all 10,058 CATTs are used and treated as separate entities, rather than being aggregated into quintiles. In this Section, the theory of suicide contagion is explored, in which clusters of suicide among younger adults are sought. This Section is followed by an example of statistically modelling the patterns of suicide, to further demonstrate the versatility of the CATTs, and also to determine if social variables other than the components of the Carstairs index of deprivation help explain the regional differences in suicide that were reported in Section 7.5. Because suicide increased among younger males between 1981 and 2001, and because suicide rates among younger females were nearly six times higher in the most deprived areas than least deprived areas in 2001, the following analyses were only conducted for the younger population.

The literature review above demonstrated that there is a tendency for suicides to cluster, either spatially and temporally in the case of a 'point' cluster, or temporally in the case of a 'mass' cluster. Moreover, in many cases point clusters often exhibit some degree of social contagion. However as this thesis is ecological in nature, it is not possible to determine whether the rising suicide rate in Scotland resulted from a mass cluster, nor is it possible to explore the possibility of social contagion in the traditional sense. Rather, this Section explores social contagion in a geographical context, in which clusters of suicide are identified under an ecological framework.

The contemporary literature on suicide clusters is predominantly from the medical community. In addition, the clusters are often defined using anecdotal evidence or traditional statistical methods (e.g. Joiner 1999, 2003; Wilkie *et al.* 1998). To test this theory in the Scottish context, cluster analysis was undertaken for suicides among all persons aged between 15 and 44 years. Moreover, to examine whether evidence of a spatio-temporal cluster existed, models were run separately for each period (1981, 1991 and 2001) and also for the entire study period (1981-2001). Note that whereas all of the previous analysis has been done by comparing changes between the 1981 and 2001 mortality and/or social data, this analysis incorporates the data from 1990-1992 ('1991'), for the first time.

Since the occurrence of suicide was relatively rare throughout the study period, the calculation of SMRs for individual CATTs would not have produced reliable results. A more appropriate approach was to assume that the occurrence of suicide 'events' at the CATT2 level conformed to the Poisson distribution, and model the relative risk of suicides through space and space-time. A number of cluster detection methods exist, but the Scan Statistic (Kulldorff 1997) has been widely used in the detection of clusters inherent in mortality (Boscoe *et al.* 2002; Sankoh *et al.* 2001; Sabel *et al.* 2003) or other health-related datasets (e.g. Green *et al.* 2003; Brooker *et al.* 2004) and was therefore used in this study to identify suicide clusters. The present analyses were undertaken using SaTScan version 4.0.2 (Kulldorff and Information Management Services Inc., 2004).

For the detection of spatial clusters, SaTScan places a circular (moving) window over the map of CATT2 centroids (grid references). The window centred on each of the CATT2 centroids positioned throughout the study region. For each centroid, the radius of the window varied continuously in size from zero to the upper limit, which was defined as 50% of the population at risk[6]. For each circle, at every location, two calculations were made, the relative risk and the log likelihood ratio. The relative risk was comparable to an SMR, in that it was the ratio of observed suicides to the expected suicides within the circle, and identified the increased or decreased risk of suicide within a circle relative to Scotland as a whole. The log likelihood ratio determined whether the suicide rate within the circle differed significantly from the suicide rate outwith the circle. The size and location of the circle with the maximum likelihood represented the most likely cluster, which in turn was the cluster that was least likely to have occurred by chance. Note that while SaTScan reports the most likely cluster, it also identifies secondary clusters. Monte Carlo simulation, a process that compares the rank of the maximum likelihood of the cluster from the actual data with the maximum likelihood from random data sets (created within SaTScan), tested the significance of the likely clusters and produced the p-values of the cluster. In all of the cases below, 'significant' clusters refer to those clusters that have a p-value of ≤ 0.05.

[6] This was the default value recommended by Kulldorff (1997)

Let N be the total number of suicides, n the observed number of suicides within a circle, and λ the expected number of deaths in the circle under the null hypothesis. Assuming that the distribution of suicides within each CATT2 conforms to a Poisson distribution, then the likelihood ratio for a particular circle would be:

$$\frac{L_a(D)}{L_0} \propto \left(\frac{n}{\lambda}\right)^n \left(\frac{N-n}{N-\lambda}\right)^{Nn} I(n > \lambda)$$

Equation 7-1 The formula for likelihood ratio computed by SaTScan

Where $L_a(D)$ is the likelihood that there is a suicide cluster in the 15-44 age group in a given circle D, L_0 is the likelihood under the null hypothesis and I is an indicator function, equal to 1 when more suicides than expected under the null hypothesis are reported within a circle, or 0 otherwise. The circle with the greatest likelihood ratio, as defined by Equation 7-2 is therefore defined as the most likely cluster.

$$\max_D \frac{L_a(D)}{L_0}$$

Equation 7-2 The statistic used to test maximise the likelihood ratio

7.6.1. Clusters Among Young Adults (15-44 Years)

Throughout this Chapter it has become clear that suicide increased among younger adults and decreased among older adults between 1981 and 2001. Furthermore, relative suicide inequalities among younger adults have also increased over time. Section 7.5 also showed that suicide rates vary geographically. However, there were only four areas considered in Section 7.5 (although they were based on the CATT2s), and it was not possible to determine whether suicide was concentrated in some parts of Scotland. Therefore, this Section uses SaTScan to locate clusters of suicide among younger adults in 1981, 1991, 2001, and 1981-2001.

The Poisson model within SaTScan (Kulldorff and Information Management Services Inc, 2004) was used for the detection of suicide clusters that occurred in 1981, 1991, 2001, and 1981-2001, for males, females and all persons aged between 15 and 44 years. Following the conventions in the previous chapters, in this analysis, the census year (1981, 1991 and 2001) represents suicides occurring between 1980-

1982, 1990-1992 and 1999-2001.

SaTScan identified five suicide clusters among younger adults (15-44) in 1981, although only one was statistically significant (Figure 7-6). It is possible for SaTScan to identify clusters consisting of a small number of CATT2s, and so the centre of the cluster (i.e. a CATT2 grid reference) has also been mapped in this analysis, denoted by a star (★). In Figure 7-6 and the maps that follow, all of the CATTs that belong to a significant cluster ($p \leq 0.05$) have been shaded black on the map, and CATTs belonging to non-significant clusters have been shaded grey. Thus, it is clear from Figure 7-6 that the only significant cluster for young adults in 1981 was located in Glasgow City. There were 92 observed suicides in this cluster, compared with 38.21 expected, with a relative risk of 2.41. Under the Poisson distribution, the relative risk is comparable to a SMR; therefore a relative risk of 1.0 indicates that the number of suicides (within a given circle) is equal to the expected.

Two significant clusters were reported for 1991 – one in Glasgow City and one in Midlothian (Figure 7-7). The cluster in Glasgow was the most significant ($p=0.001$) and comprised 600 CATT2s, in which there were 159 suicides compared with 78.54 expected between 1990 and 1992, with a relative risk of 2.02. In contrast, the Midlothian cluster contained 26 suicides within 75 CATT2s. SaTScan estimated 8.3 expected deaths in this cluster, and therefore reported a relative risk of 3.13. Although the relative risk for the Midlothian was greater than that reported for the Glasgow City cluster (2.02), it was slightly less significant with a p-value of 0.031. There appears to be three components to the Midlothian cluster in Figure 7-7, however this is not the case. The grid references for the CATT2s were population weighted and as this particular cluster was located on the outskirts of Edinburgh city, some of the neighbouring CATT2s were very large. As a result, the circles created by SaTScan potentially include centroids that are proximal, but the CATTs not necessarily contiguous. This might occur when lochs or other water bodies separate two or more CATT2s. Despite SaTScan identifying 11 clusters in 2001 (Figure 7-8), the only significant cluster was located in Glasgow City ($p=0.001$). There were 1,053 CATT2s in this cluster in which there were 245 suicides, whereas only 160.70 were expected. Although this cluster was the largest significant cluster found for younger people across the three periods it also had the lowest relative risk

(1.525).

The data from 1981, 1991 and 2001 were merged in order to identify spatial and spatio-temporal clusters of suicide. An 'adjustment' file was created to account for the missing data between 1983 and 1989, and also for 1993-1998. Kulldorff *et al.* (1998) proposed an extension to the conventional spatial scan statistic that enabled the identification of spatio-temporal clusters. Graphically, whereas circles are placed upon the map for the detection of spatial clusters, a cylinder is used for the detection of spatio-temporal clusters. The diameter of the cylinder represents the extent of the spatial cluster while the height of the cylinder represents the temporal dimension. Figure 7-9 shows that there were six spatio-temporal clusters of suicide among all persons aged between 15 and 44 years, although only the cluster in Glasgow City was statistically significant (p=0.001). Indeed, the spatio-temporal cluster contained 562 CATT2s that was only significant for the period 1/1/1980 – 31/12/1981. During this time, 117 suicides occurred while only 47.82 were expected, resulting in a relative risk of 2.45. Another point of interest was that in spite of the attention the Highlands and Islands has received for the relatively high suicide rates over the past twenty years, SaTScan failed to locate any clusters in the Highlands. The other (insignificant) clusters were located in Midlothian, Edinburgh (x2), Dundee City and Aberdeenshire.

7.6.2. Clusters Among Younger Males

Earlier in this Chapter (and also in Chapter Five), it was shown that suicides have increased over time, particularly among young men. Comparable findings have been shown for England and Wales (Gunnell *et al.* 2003) and between 1981 and 2001 in Scotland (McLoone and Boddy 1994; McLoone 1996; Boyle *et al.* forthcoming). Therefore the cluster analyses were repeated for younger males.

Figure 7-10 shows that SaTScan identified five potential suicide clusters among younger males for 1981, although the only significant cluster was located in Glasgow City (p=0.001). This cluster contained 337 CATT2s, in which 65 suicides were committed compared to 25.07 expected, and had a relative risk of 2.59. The only significant cluster (p=0.001) identified among younger male suicides for 1991 (Figure 7-11) was located in Glasgow City. There were 122 suicides among young men in this cluster, spread amongst 651 CATT2s. However, only 64.84 suicides were expected within these CATT2s, and therefore the relative risk for this cluster was 1.88. The results from the cluster analysis for younger males in 2001 are shown in Figure 7-12. Once again, the significant cluster (p=0.008) was located in Glasgow City, although this cluster was considerably smaller than the clusters found for younger males in 1981 and 1991. The significant cluster for 2001 contained 287 CATT2s, in which there were 67 observed suicides, compared with an expected 33.21 suicides, resulting in a relative risk of 2.02.

Figure 7-13 shows the results from the spatio-temporal analysis of younger male suicides between 1981 and 2001. The only significant cluster was located in Glasgow City, which contained 384 CATT2s and experienced 66 suicides between 1/1/1980 and 31/12/1981. During the same time SaTScan estimated that 25.03 deaths were expected in this cluster, therefore during this two-year period, the relative risk of young male suicides was 2.64. The centroids of the spatial clusters for the younger male suicides (i.e. Figure 7-10 -Figure 7-12) were all located within 1,050 metres from the centre of the space-time cluster for males.

7.6.3. Clusters Among Younger Females

The number of suicides among younger females decreased significantly between 1981 and 2001. Despite this favourable trend, younger females had a wider suicide gap than younger males in 2001 with a relative inequality ratio of 5.77 (Table 7-3). The widening gap resulted from a significant decrease in the suicide rate in the least deprived areas and a substantial (but not significant) increase in the deprived areas. However, the inequalities do not determine whether the occurrence of suicide among younger females clusters spatially, therefore SaTScan was used once again to test for spatial clusters in 1981, 1991 and 2001 and to test for spatio-temporal clusters throughout the period 1981-2001.

The results of the spatial scan statistic for the 1981 period is shown in Figure 7-14. There were eight clusters identified, but only one of these was significant (p=0.014) and was located in Glasgow City. There were 29 suicides among females aged between 15 and 44 within the 429 CATT2s in the Glasgow City cluster, but only 9.96 suicides were expected. Thus, the relative risk of suicide in this cluster was 2.91.

Figure 7-15 shows the results for 1991, in which the only significant cluster (p=0.001) was located in Glasgow City. The significant cluster for 1991 contained 757 CATT2s, in which 20.07 suicides were expected among younger females. However, 51 suicides occurred in this cluster, consequently the relative risk was 2.54. The only significant cluster (p=0.001) in 2001 was also located in Glasgow City (Figure 7-16). There were 676 CATT2s belonging to this cluster, in which the relative risk was 2.25 due to 56 suicides among younger females occurring compared to 24.91 expected under the null hypothesis.

The space-time analysis (Figure 7-17) identified one significant cluster, which was situated in Glasgow (p=0.001). Interestingly, this cluster was notably larger than any of the other clusters discussed thus far – in terms of the number of CATT2s (1,717) that it contained[7]. In addition, despite the large membership of CATT2s to this cluster, 73 suicides occurred between 01/01/1980 and 31/12/1981 while only 30.35 were expected. The relative risk for this particular cluster was 2.41, which was slightly lower than the relative risk reported for the entire 1980-1982 period, but notably higher than the risk reported for the 2001 period.

In summary, the results for the cluster analyses (Figure 7-6 - Figure 7-17) convey one message: that between 1981 and 2001 suicides among younger adults (whether considering males and females separately or combined) appear to have clustered in Glasgow City. The only exception to this finding was a small significant cluster located in Midlothian for younger adults in 1991 (Figure 7-7). A number of points should be emphasised. First, although suicides have increased over time (especially for younger males), the significant space-time clusters were reported for males, females and all younger adults during the 1981 period.

Second, the Council Area in which the CATT2 representing the centre of a significant cluster fell was used to define the location of the cluster and therefore did not take into consideration the geographic extent of the clusters. Figure 7-18 shows that while the centre of each of the space-time clusters identified for younger adults, males and females was located in Glasgow City, the CATT2s that belonged

[7] Note that some clusters might cover a larger area in spite of containing fewer CATT2s. For example, this might occur at the urban fringes, or where one or more CATT2 zones contain industrial estates.

to the clusters sprawled over into neighbouring Council Areas. For example, the majority of the CATTs assigned to the space-time cluster for younger males were located in Glasgow City, but a small number of the CATT2s were located in South Lanarkshire. The cluster for younger adults contained all of the CATTs belonging to the younger males' space-time cluster, but extended further to the North, into East Dumbartonshire. Similarly, the space-time cluster for younger females contained all of the CATT2s that defined the space-time clusters for younger males and younger adults, but covered a considerably larger area, broadening the area of greatest suicide risk to incorporate East Renfrewshire, North Lanarkshire, East Dunbartonshire and West- Dunbartonshire, and the South Western corner of the Stirling Council Area.

Third, there appear to be a number of non-contiguous clusters at the fringes of the space-time clusters shown in Figure 7-18. These have occurred because SaTScan uses a point-based methodology. Therefore, it was possible that two points (CATT2 centroids) were adjacent, even though their respective boundaries were not. This might occur when one relatively large CATT placed between two smaller CATTs comprised non-residential land (e.g. industrial site, hospital, woodland) and had a population-weighted centroid outwith the radius of the circle under investigation by SaTScan.

Fourth, the area that fell within the suicide clusters shown in Figure 7-18 included some of the most deprived parts of Scotland and the UK, such as the Glasgow Shettleston and Glasgow Springburn Parliamentary Constituencies. The Constituency Profiles (PHIS 2004) reported the general health and well being of the Scottish population at the Parliamentary Constituency level. The profiles revealed that East Glasgow was considerably poor. For example, males living in the Glasgow Shettleston Constituency in the 1999-2001 period had a life expectancy of 63.9 years, while for females the life expectancy was 75.2 years, 12.9% and 4.4% lower than the Scottish average respectively. In addition, 32% of the population in the Shettleston Constituency reported a limiting long-term illness, 35% of the households comprised lone parents, 34% were income support claimants, and the crude rate of prescriptions of antidepressant related medicine was 10% above the Scottish average (PHIS 2004).

The average age-standardised rate of hospital admissions due to suicide and/or deliberate self-harm for the 1999-2001 period in Glasgow was 510.3, some 68% higher than the Scottish average. In addition, there were 38% of males and 13% of females that reported consuming more than the recommended weekly limit of alcohol in 1998. There were 2,923 new patients requiring treatment for drug misuse in Glasgow during the 2002-2003 period, which represented an age-standardised rate of 447.5 per 1,000, 88.7% above the Scottish average (PHIS 2004).

In contrast, there were 178 new patients for drug-misuse treatment during the same period in the Highlands, a rate of 105.0 per 1,000, 56% less than the Scottish average. Similarly, between 1999 and 2001, the average rate of suicide and/or deliberate self-harm hospital admissions was 176.2 per 100,000, 42% fewer than average. In 1998, 25% of males and 12% of females consumed more than the recommended weekly limits of alcohol, and the average life expectancy between 1999 and 2001 in the Inverness East, Nairn and Lochaber Parliamentary Constituency was 75.2 for males and 80.4 for females (PHIS 2004).

Finally, although the spatial clusters (i.e. for 1981, 1991 and 2001 separately) each had their centre in Glasgow City and were proximal to one another, deprived inner city areas is not a geographically based priority group in the *Choose Life* strategy (Scottish Executive 2002b). The only priority group defined geographically in the strategy were 'isolated or remote areas'.

While there is no doubt that SaTScan has identified significant spatial and spatio-temporal clusters of suicide in Glasgow, the results have only been standardised by age and sex. If other ecological variables such as social deprivation, migration, housing tenure and occupancy were taken into consideration, it is possible that the elevated risk of suicides in Glasgow would weaken, while the importance of rurality and isolation would strengthen, thus supporting the only geographic priority group in the *Choose Life* report (Scottish Executive, 2002b). Therefore, the following Section examines suicide among younger adults at the CATT2 level, and uses a selection of social variables available from the census to model suicide trends over time. Note that the analysis in the following Section is not aimed to identify suicide clusters. Rather, the models adopted are employed to determine which social factors appear to be related to suicide at the local level.

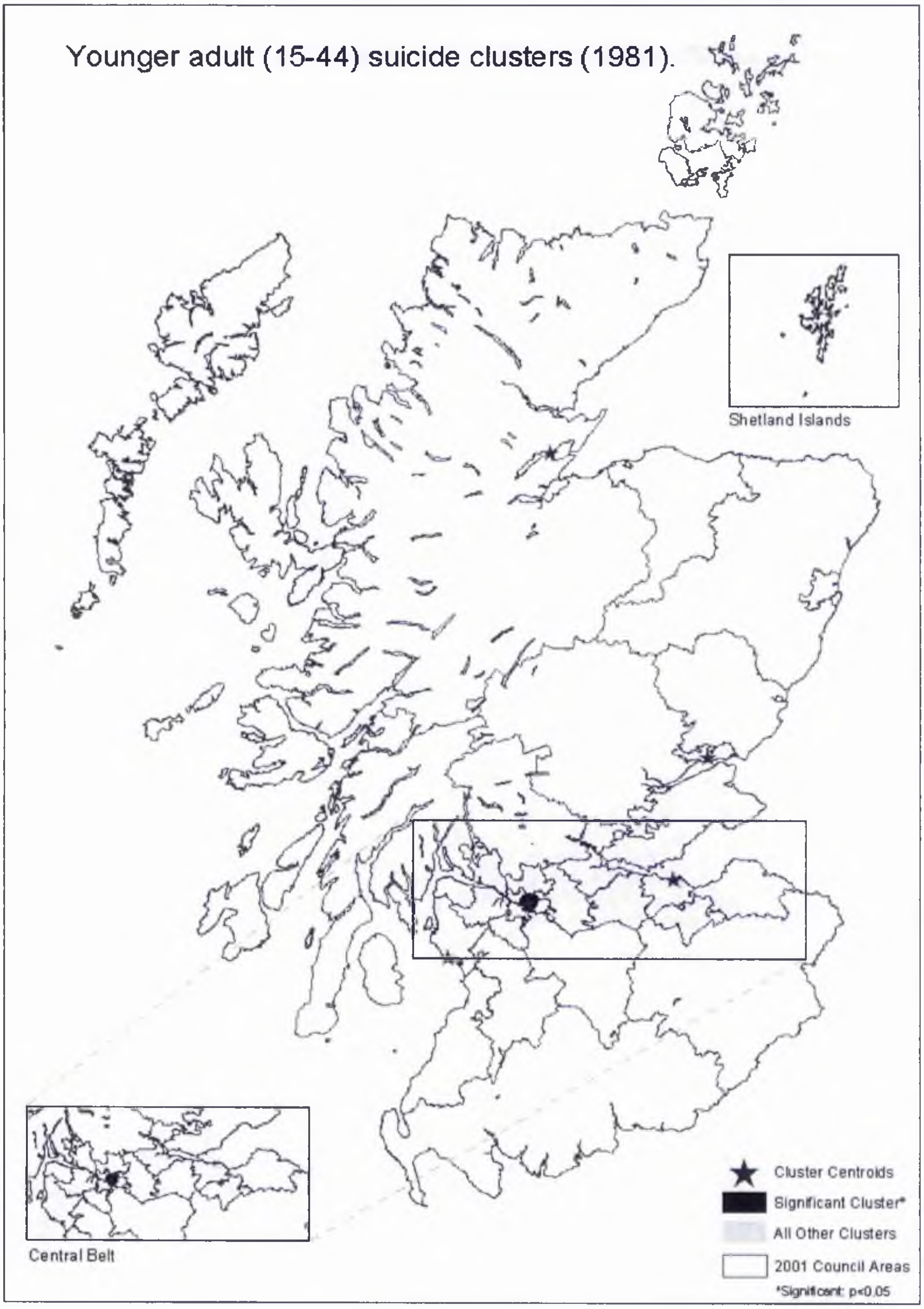

Figure 7-6 Suicide clusters among younger people, 1981

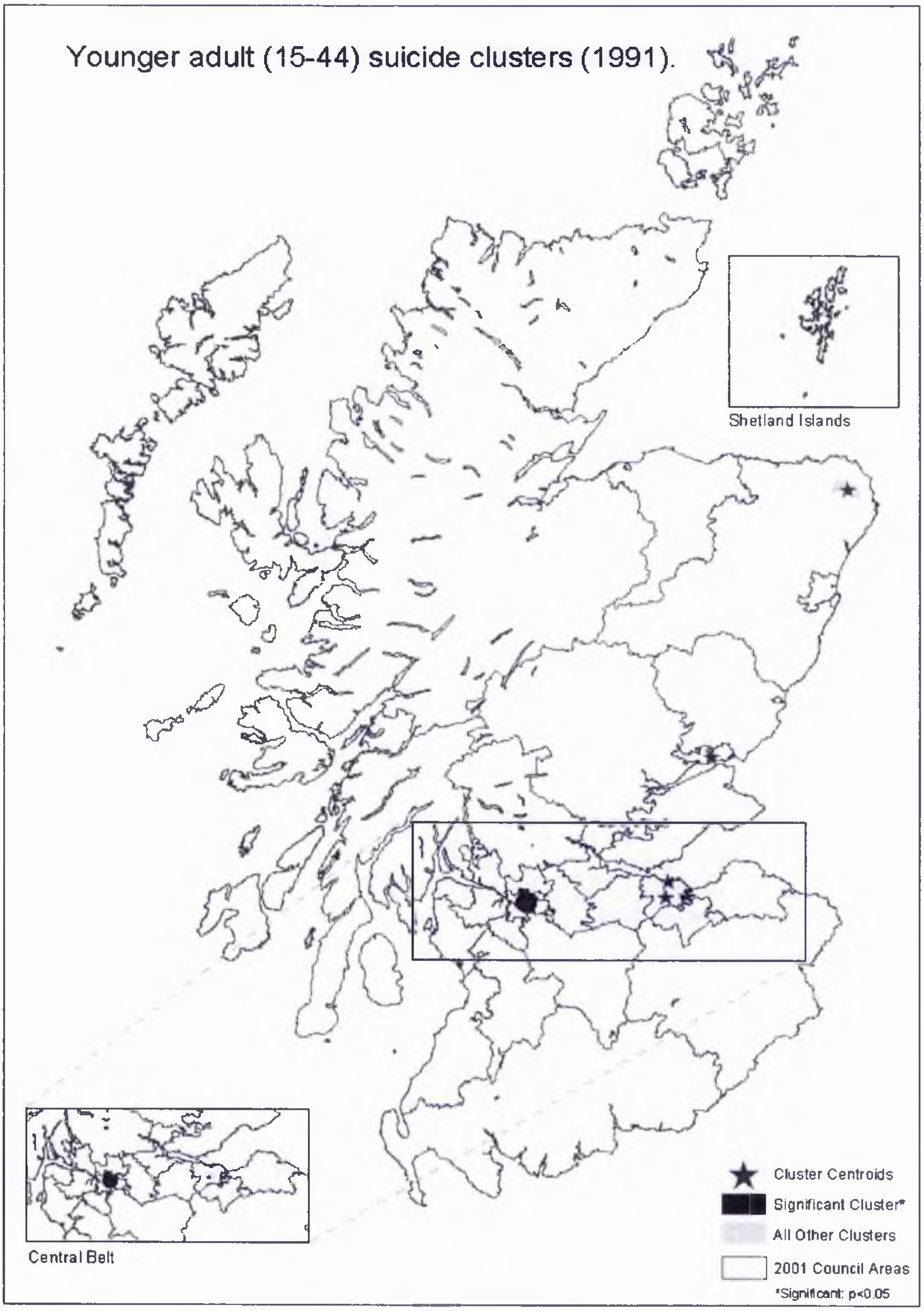

Figure 7-7 Suicide clusters among younger people, 1991

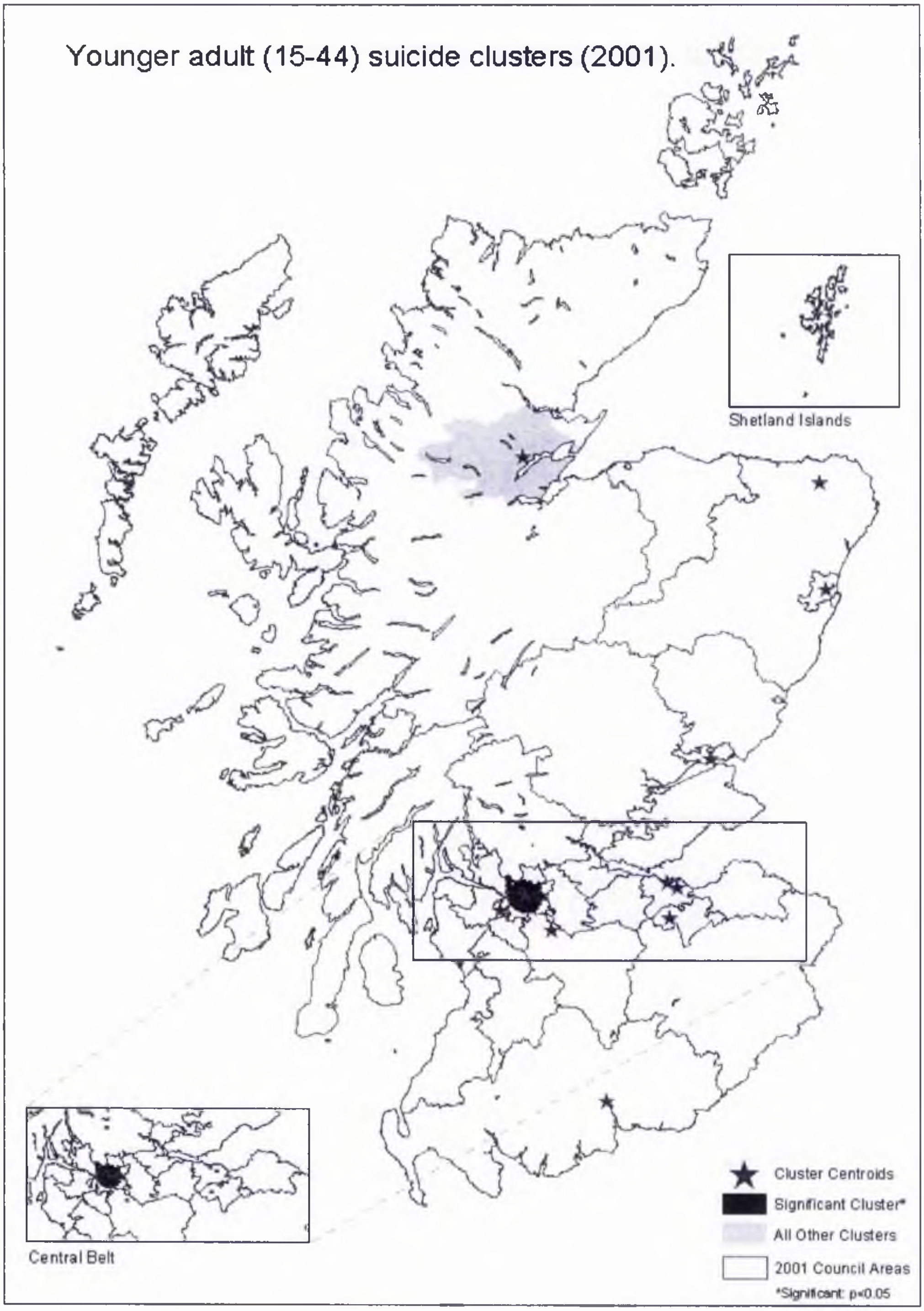

Figure 7-8 Suicide clusters among younger people, 2001

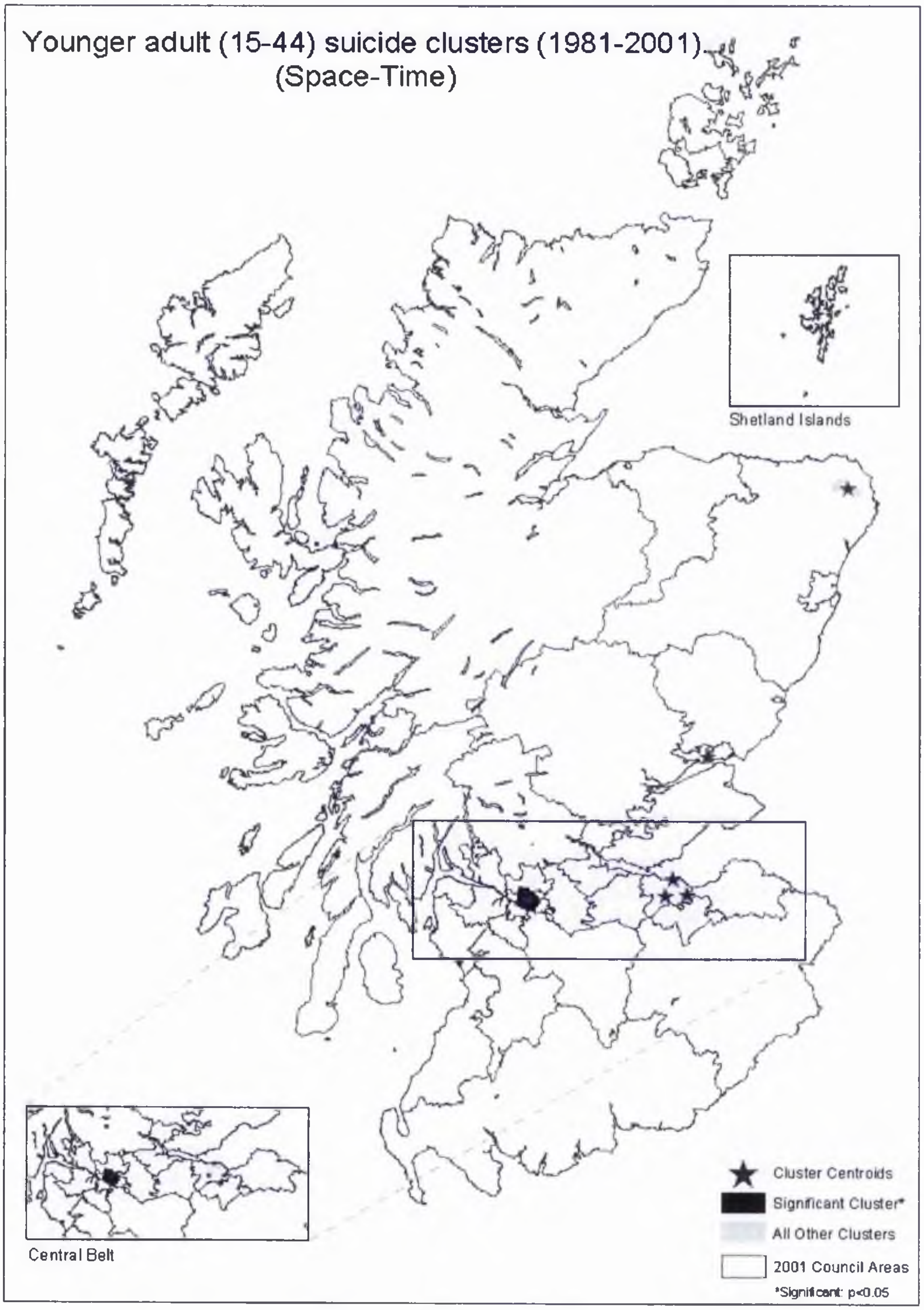

Figure 7-9 Spatio-temporal suicide clusters among younger adults, 1981-2001

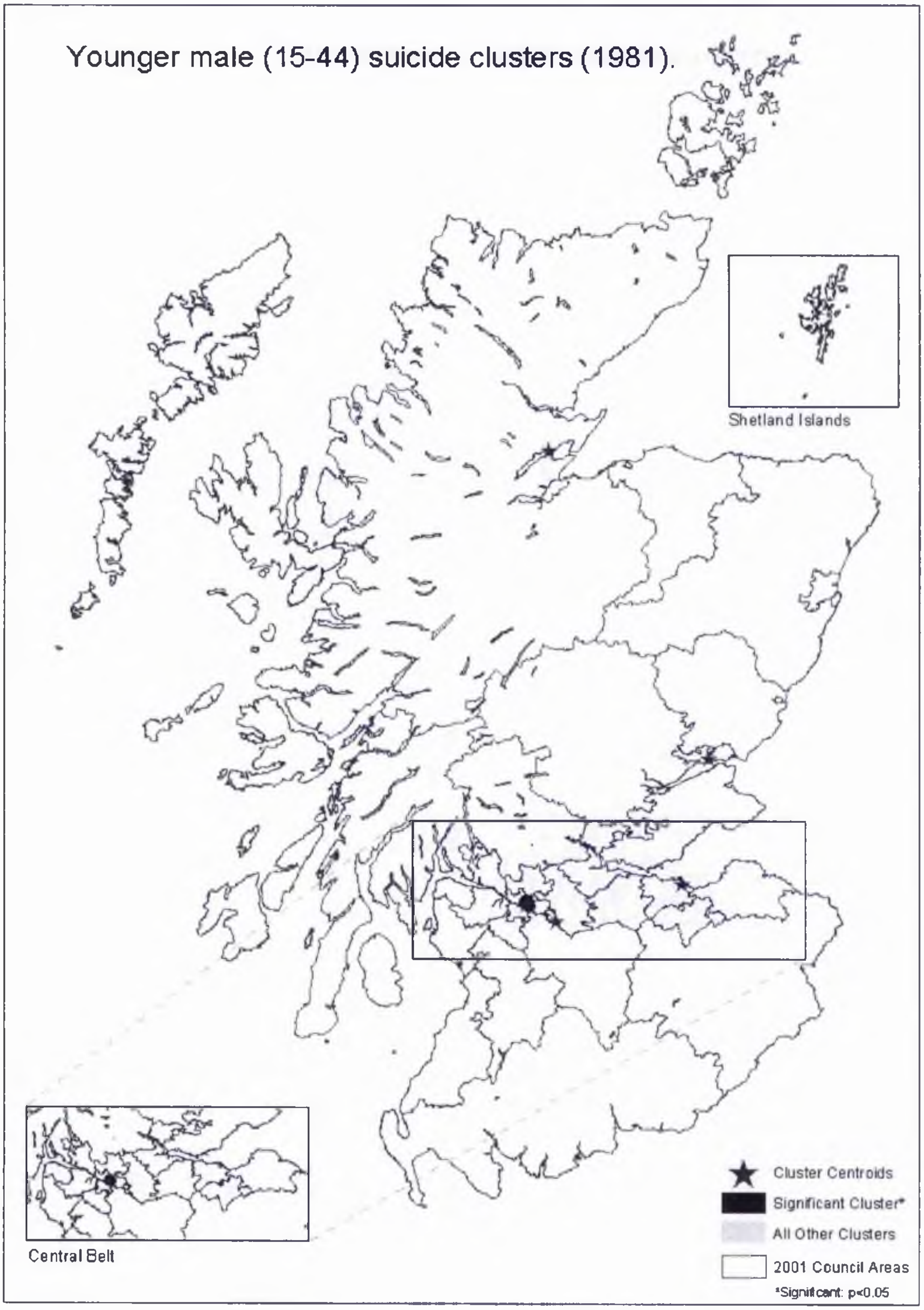

Figure 7-10 Suicide clusters among younger males in 1981

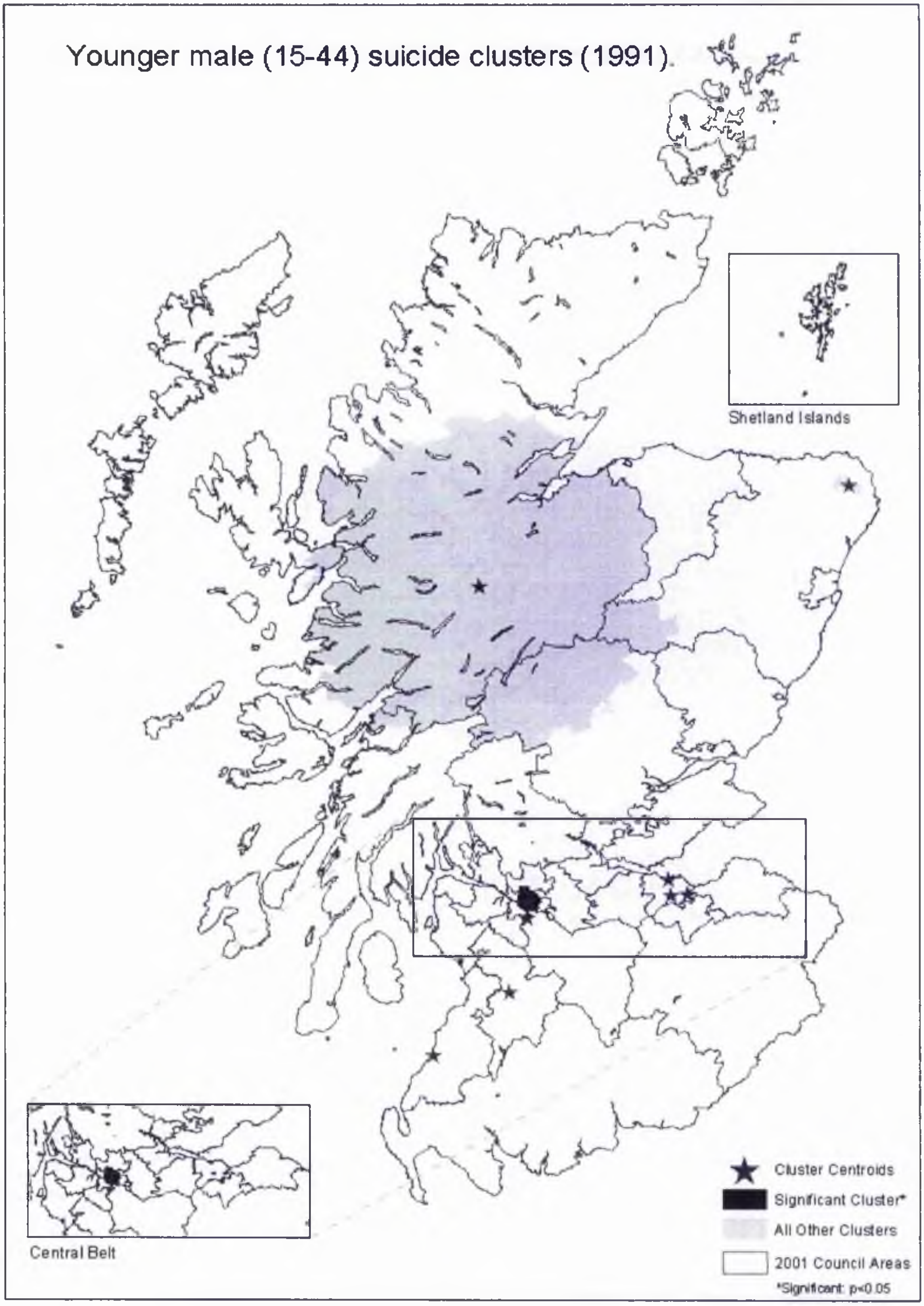

Figure 7-11 Suicide clusters among young males, 1991

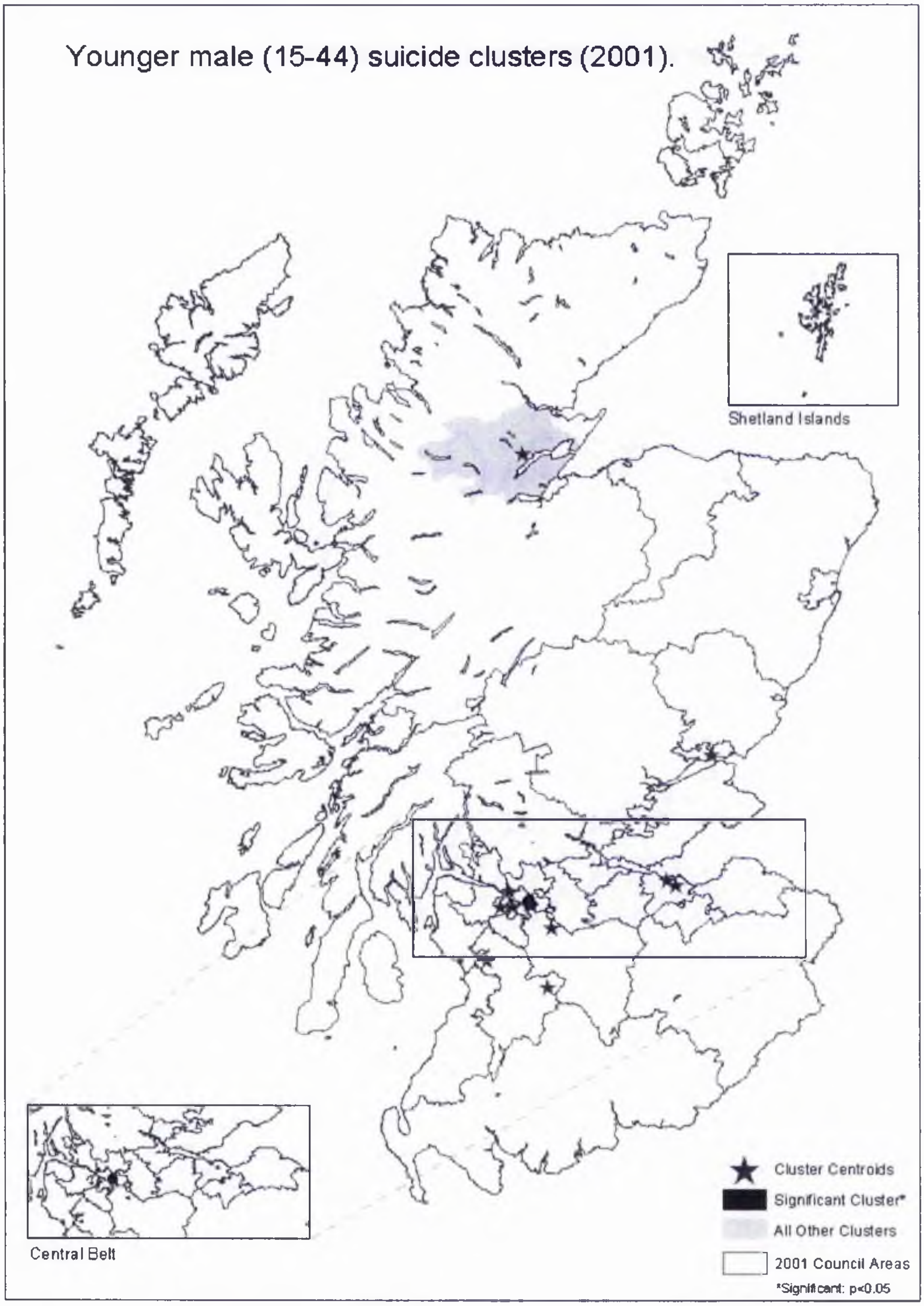

Figure 7-12 Suicide clusters among younger males, 2001

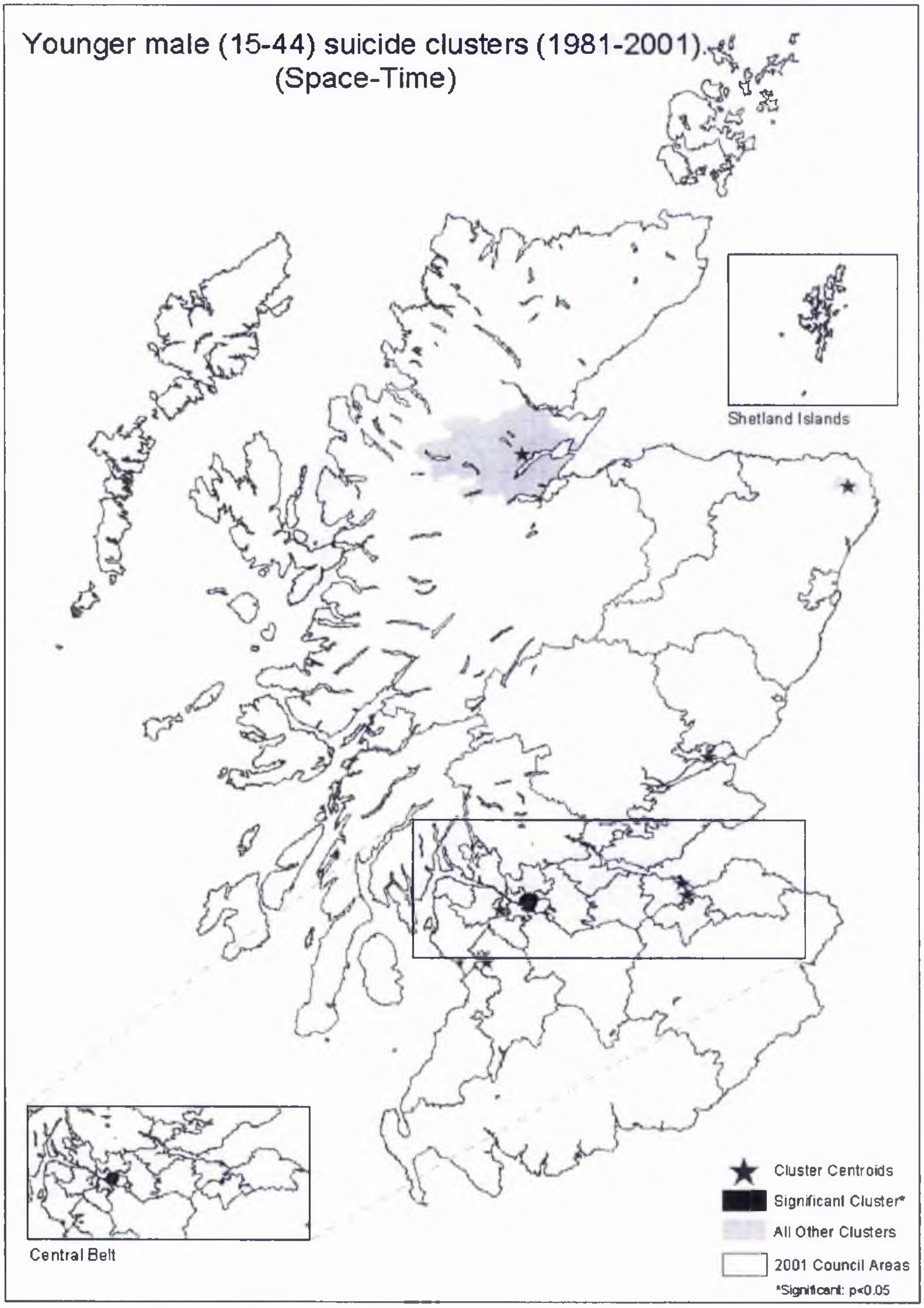

Figure 7-13 Spatio-temporal suicide clusters among younger males, 1981-2001

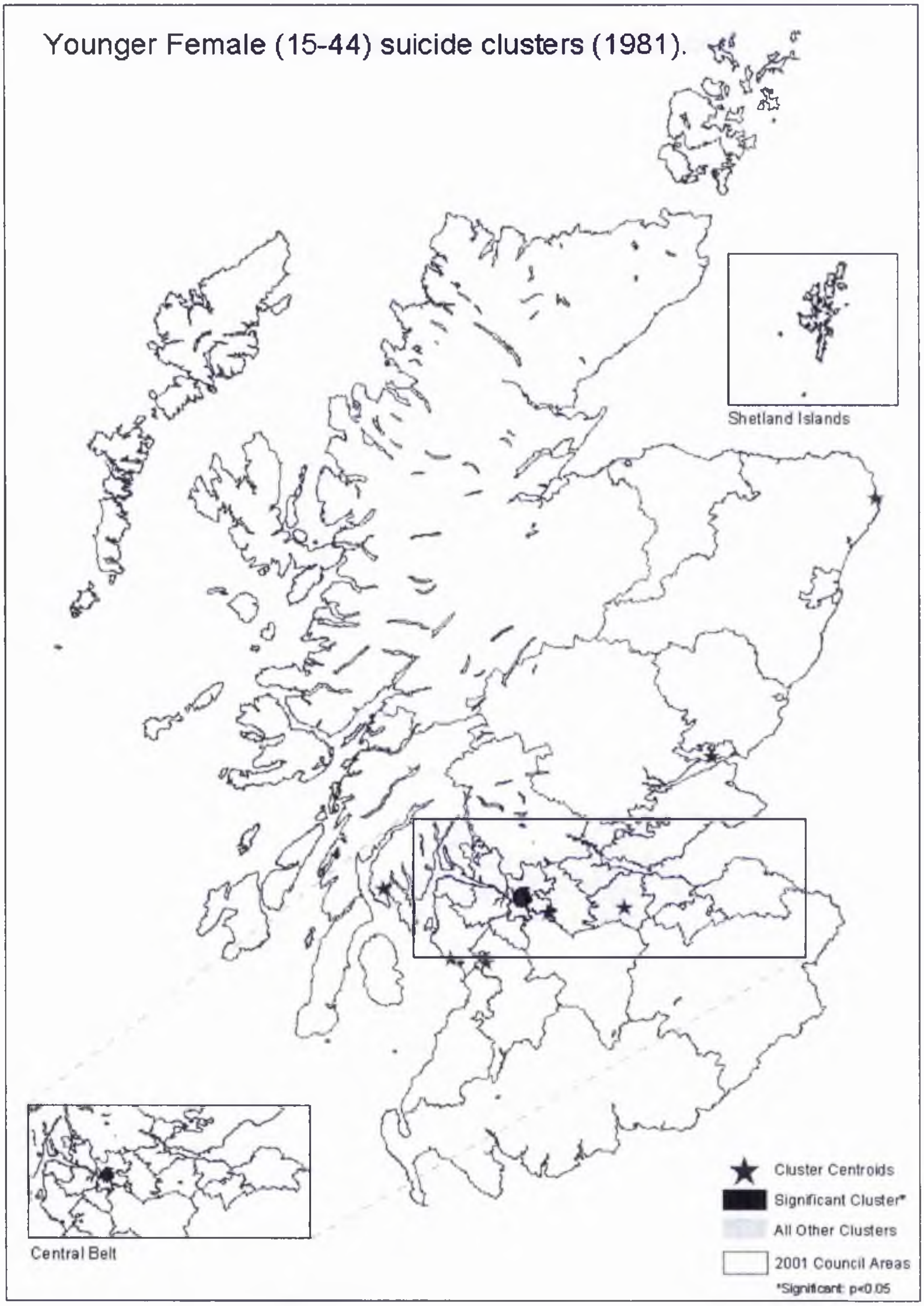

Figure 7-14 Suicide clusters among younger females, 1981

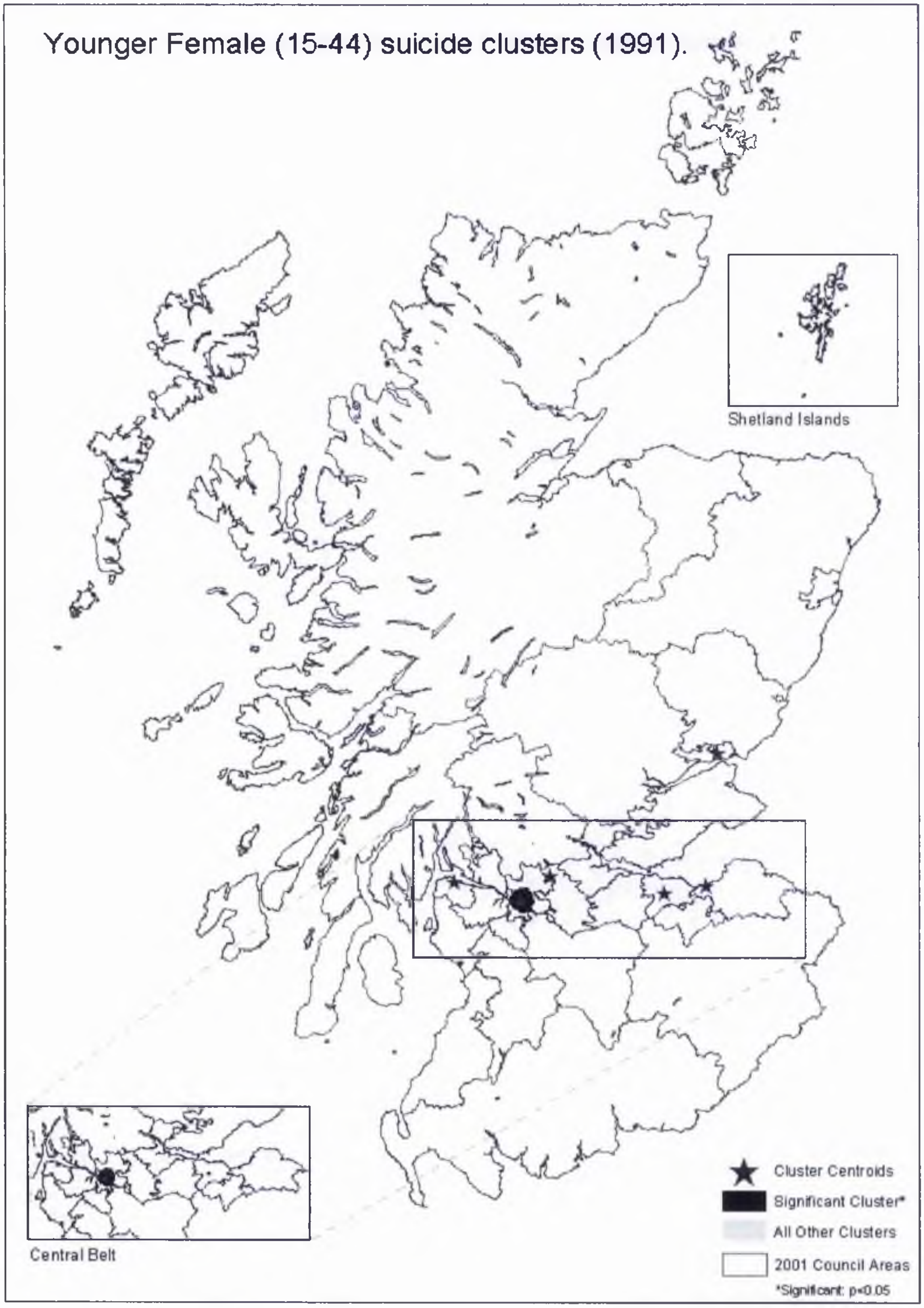

Figure 7-15 Suicide clusters among younger females, 1991

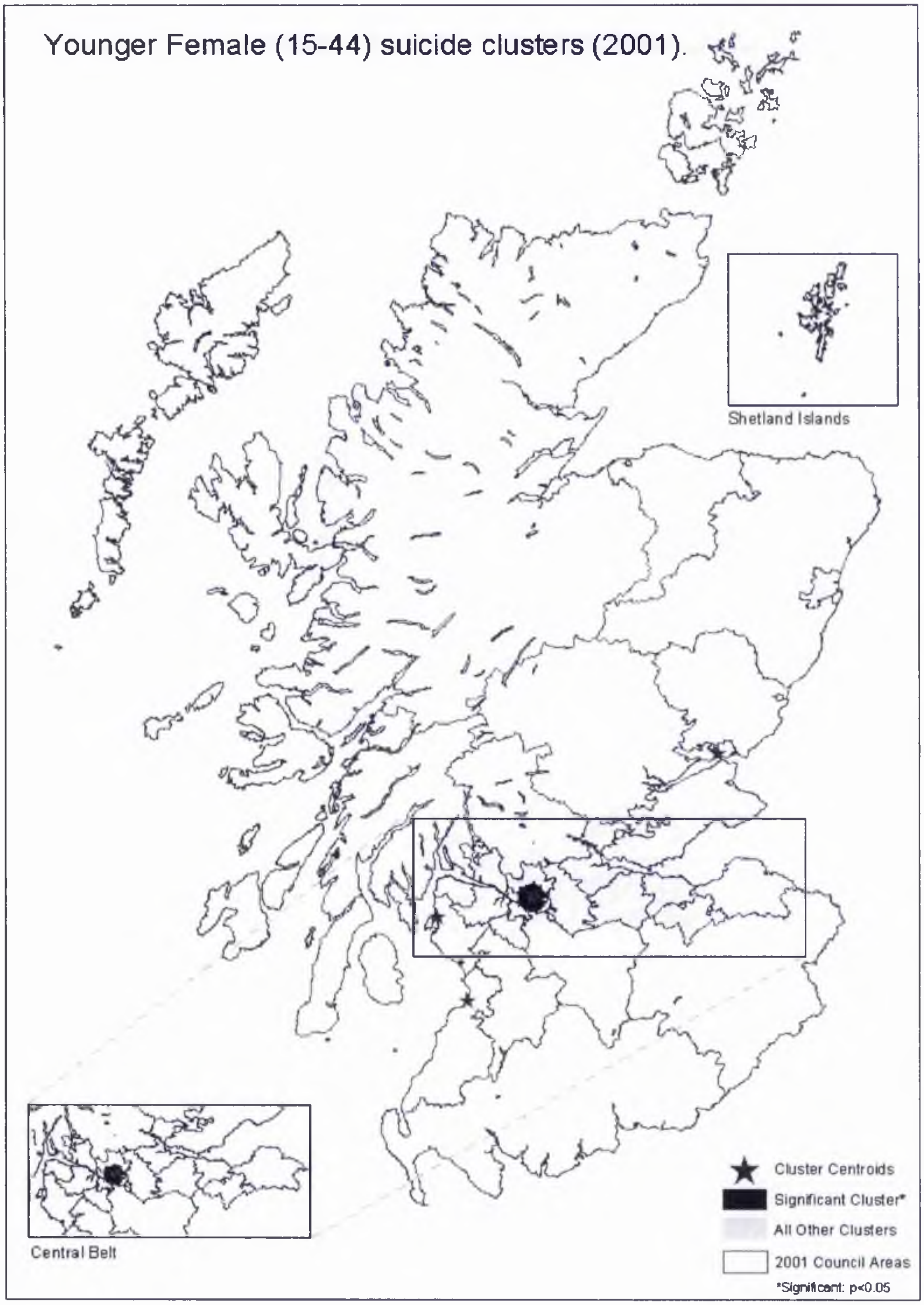

Figure 7-16 Suicide clusters among younger females, 2001

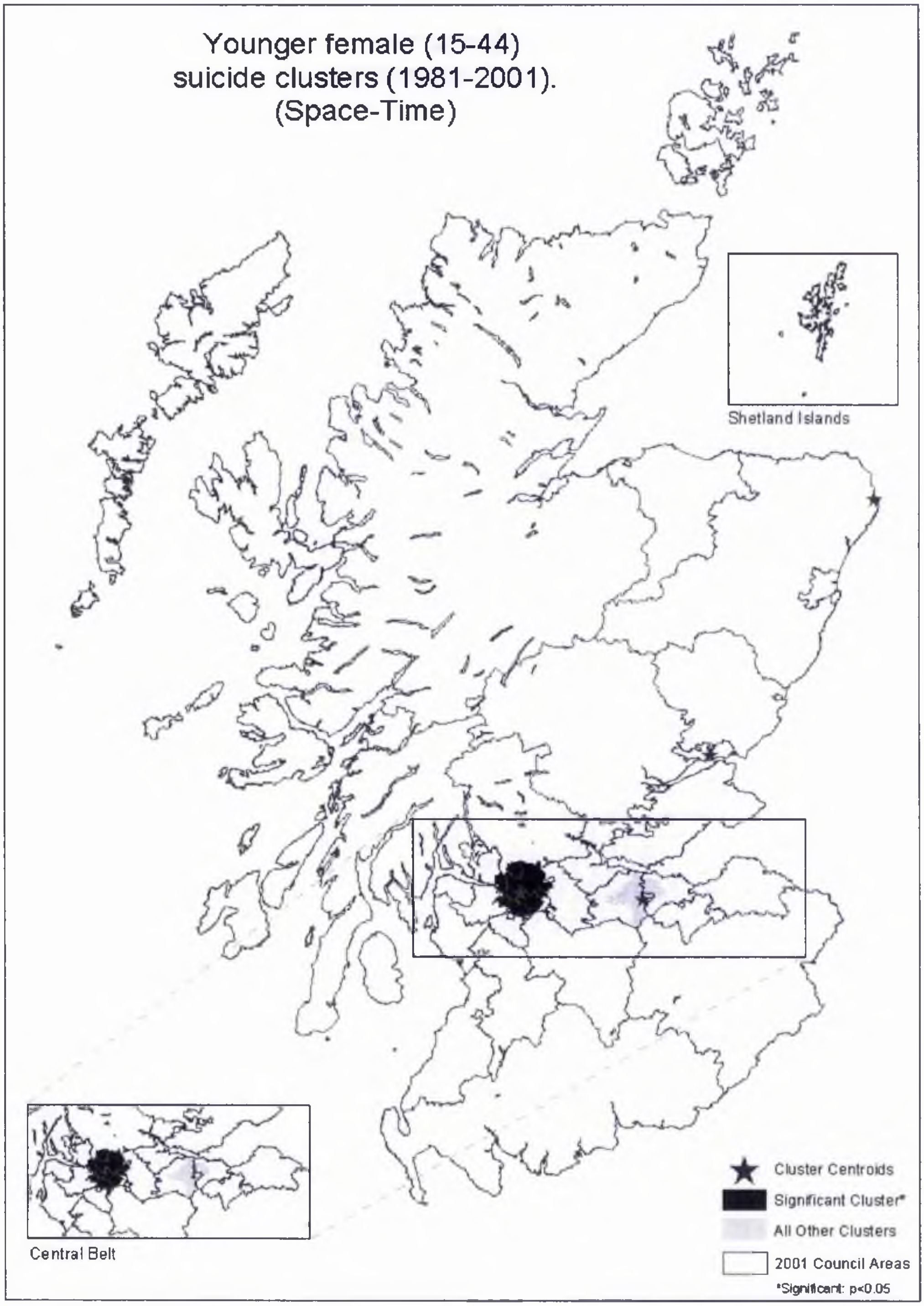

Figure 7-17 Space-time suicide clusters among younger females, 1981-2001

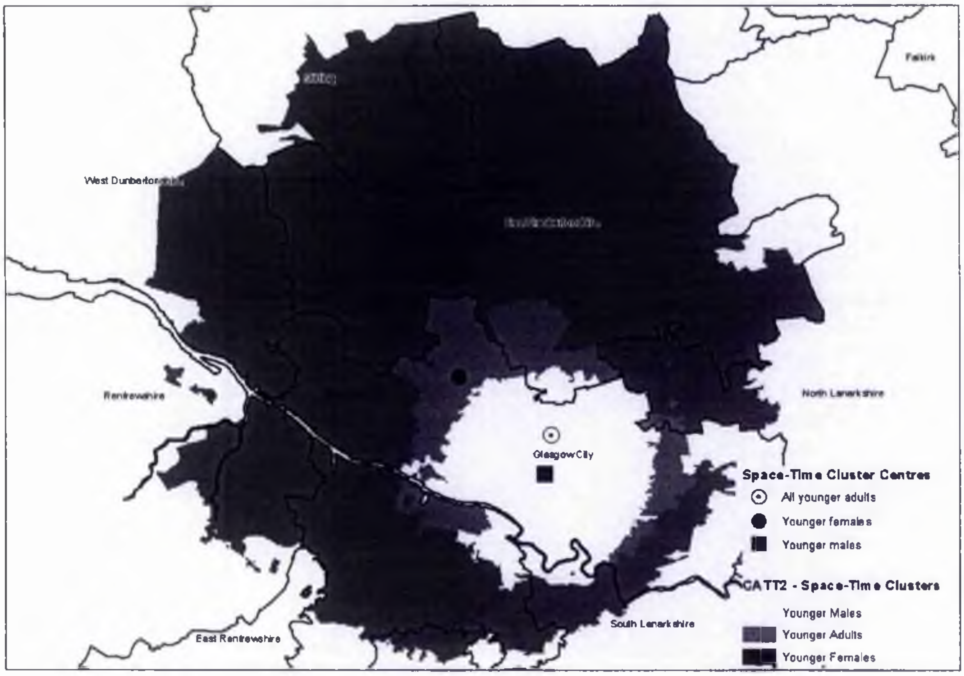

Figure 7-18 Significant space-time clusters in Glasgow, for all younger adults, younger males and younger females

7.7. Social Conditions and Suicide Among Younger Adults

This Section examines the relationship between the social environment and suicide among younger adults (15-44 years). A number of important social factors have been associated with elevated (or reduced) suicide risk. Factors shown to influence suicide risk include: unemployment, in-migration, deprivation, being divorced, and single occupancy accommodation. It should be appreciated that personal factors (i.e. drug use, depression, mental health problems) are also very important, but it is difficult to gather ecological data on these variables. One would expect the social factors to vary spatially, and should therefore be controlled for. In this Section, an attempt is made to explain suicide at the CATT2 level using social factors obtained from the 1981, 1991 and 2001 census.

Recent studies (Middleton *et al.*, 2003; Gunnell *et al.* 2003; Dorling and Gunnell 2003) have used a negative binomial model rather than a Poisson model in their attempts to predict the association between social variables derived from census and/or administrative data and suicide. The negative binomial model is used in favour of the Poisson model when the data are over-dispersed. Over-dispersion refers to instances where the variance of a Poisson is greater than the mean, thus breaking the assumption that the variance equals the mean. In this study, the count of suicides among younger males and females (separately and combined) in each CATT2 from 1980-1982 (1981), 1990-1992 (1991) and 1999-2001 (2001) were pooled and used in a Poisson model to explore the relationship between suicide and social conditions. These data were also modelled using a negative binomial distribution, but the results were not significantly different. Because each zone in the CATT2 boundary file is consistent through time, it was thought that a longitudinal data analytical framework would be more appropriate than a typical pooled cross Sectional approach. Therefore, the cross-sectional time-series (i.e. longitudinal) variant of the negative binomial model was used to predict suicide within STATA (version 8.0 SE).

However, the results from the longitudinal model were not significantly different to the results obtained from a pooled cross-sectional model. Moreover, the results from the cross-sectional time-series model were almost identical (most coefficients were identical to 3 decimal places) to the results obtained from the standard Poisson model. Although the CATT2s were consistent through time, the variables chosen for the modelling changed considerably, and a pooled cross-sectional Poisson model was more appropriate than either a pooled cross-sectional, or a longitudinal negative binomial model. Therefore, this Section reports the results from the pooled cross-sectional Poisson models. However, before the results from the models are examined, the Poisson distribution and the variables chosen are discussed.

7.7.1. The Poisson Distribution

The Poisson distribution is appropriate when the observed variable is a count, particularly when there are many observations of very low values, and also when events are considered to occur independent of each other (Lovett and Flowerdew 1989). Thus, as suicide is a particularly rare cause of death, occurring within a small proportion of CATT2s, these data suited the criteria of the Poisson distribution. Poisson regression describes the probability that a suicide occurs *n* times during a fixed period, under the assumptions that each suicide is independent and has a constant probability (Lovett and Flowerdew 1989).

The Poisson distribution is a form of generalised linear modelling in which the natural logarithm of the estimate is equal to the linear combination of the corresponding values of the independent variables. When only one independent variable under consideration, the predicted value of the dependent variable for case *i* is the maximum likelihood estimate (λ_i) of the mean of a Poisson distributed variable Y_i, and can be formally written as:

$$\ln(\hat{\lambda}_i) = \beta_0 + \beta_1 x_i$$

an alternative expression, which takes the Poisson equivalent of a linear regression equation, is:

$$\hat{\lambda} = \exp(\beta_0 + \beta_1 x_i)$$

Poisson regression has been used to analyse a number of health outcomes. For example, Morrell *et al.* (1999) used Poisson regression to examine differentials among urban and rural suicides. In addition, they compared the rates of suicide among immigrants with Australian born victims. They concluded that suicide among male migrants in less urban settings accounted for most of the excess male suicide in rural parts of New South Wales. The suicide risk was significantly lower for Australian born females, but was higher for immigrant females.

7.7.2. Variable Specification

The social variables derived from the three census periods are provided in Table 7-6. As the focus of this analysis was on suicide among males, females, and all people aged between 15 and 44 years, one might have expected the explanatory variables to fall within this age group. This was not possible for any of the variables used due to changes that were made in the dissemination of census results between 1981 and 2001. For example, in 1981, the unemployment data were disseminated for the 16-19, 20-24, 25-29, 30-34, 35-39 and 40-44 age groups (1981 SAS Table 09). In 1991, unemployment data were available for similar age groups (16-19, 20-24, 25-29, 30-34, 35-44) (1991 SAS Table 08), but in 2001 (2001 Table CS028) the age groups were altered considerably. First, the 16-19 age group used in the 1981 and

1991 censuses was split to form two groups (16-17, 18-19), which would obviously not affect the data requirements in this analysis. Second, the 35 to 44 age category used in the 1991 census was changed to cover the economically active population aged between 35 and 54 years in 2001. In addition, the unemployment data were also disseminated with different upper age limit classifications over the three censuses. In 1981 and 2001, the last age group was 75+, while in 1991 it was 65+. Thus, in this analysis the proportion of the population unemployed was defined as males, females or all people aged between 16 and 64 (inclusive).

Similar alterations were made to the tables reporting marital status (%singlePerson, %msingle, %fsingle in Table 7-6). In 1981 and 1991, 15 year olds were considered as a distinct group, but in 2001 this was changed and they were grouped together with the population aged 0-14 years. Therefore, in this analysis, the proportion of the population who were single[8] was restricted to residents aged between 16 and 44 years. The variable representing the single population comprises individuals that had never married, as well as individuals who were divorced and individuals that were widows. A more appropriate measure might have been to consider only those individuals that were divorced, however such a variable was not available through standard census tables.

[8] For each census 'single' included residents that had never married as well as those who had divorced and/or widows.

Variable Name	*Description*
CATT2ID	Numeric Area Identifier
Census	Census Period Marker (1981 = 1; 1991 = 2; 2001 = 3)
TotalSuicide	All Suicides 15-44
MaleSuicide	Male Suicides 15-44
FemaleSuicide	Female Suicides 15-44
LogTotalPop	Log Total Pop 15-44
LogMalePop	Log Male Pop 15-44
LogFemalePop	Log Female Pop 15-44
Areatype	1) Highlands, 2) Glasgow, 3) Other Cities, 4) All Others
%tunemployed	% Unemployed (16-64)
%munemplyed	% Males Unemployed (16-64)
%funemployed	% Females Unemployed (16-64)
%migration	% Migrants
%notowncar	% No Car Ownership
%crowdHouses	% People in Crowded Houses
%lowSocClass	% Low Social Class (IV & V)
%1perHhold	% Single Occupancy Housing
%rentedAccom	% Non-Owner Occupied Housing
%msingle	% Single Males (16-44)
%fsingle	% Single Females (16-44)
%singlePerson	% Single (16-44)

Table 7-6 Variables used to model suicide among younger people (15-44)

The %migration variable in Table 7-6 represents the proportion of residents in a CATT2 that had moved house in the 12 months prior to census night. In 1981, SAS Table (08) reported counts of male and female migrants aged 0-15, 16-24, 25-29, 30-34, and 35-44. The comparable SAS Table in 1991 (15) reported the total number of migrants by age group (0-15, 16-29, 30-44), but aggregated the data in terms of the distance migrated (e.g. within Postcode Sectors, between Sectors but within District, between Districts but within the same Region, from England and Wales, from outside Great Britain, between neighbouring Districts and between neighbouring Regions/English Counties). The only data available for 2001 at present are the counts of migrants (males, females, and all persons) for 0-15, 16-pensionable age, pensionable age and over. For consistency, the %migration variable refers to the total number of migrants (males and females combined) and does not take into consideration the distance travelled by the migrants.

The remaining variables derived from the census data (%notowncar, %crowdHouses, %loSocClass, %1perHhold, %rentedAccom) were not calculated for age groups but for the total population. Of these variables, three (%notowncar, %crowdHouses, %lowSocClass) are the variables used to construct the Carstairs index of deprivation. While loneliness is a very personal and multi-faceted emotion, it is represented in the model by the %1perHhold variable. This variable represents the proportion of households within a CATT2 with only one resident, under the assumption that an individual living on his or her own may have an elevated risk of feeling either isolated or lonely, which are both factors associated with suicidal tendencies. Finally, the %rentedAccom variable accounts for the proportion of the population within each CATT2 that do not own their own home. Note that whereas Whitley *et al.* (1999) used the proportion of private renters in their index of social fragmentation, in this analysis all rented accommodation has been included in the %rentedAccom variable.

The areatype variable is based on the same area classification used in 7.5, and categorises the CATT2s into four groups: 1) Highlands and Islands, 2) Glasgow, 3) Other Cities, and 4) All Other Areas. The CATT2ID variable is a unique numeric value representing a CATT2, while the 'Census' variable distinguishes data derived from the 1981 (wave 1), 1991 (wave 2) and 2001 (wave 3) censuses and mortality datasets. Thus, there are 30,174 rows (10,058 CATT2s x 3) in the dataset used for this analysis.

7.7.3. Modelling Suicide Risk – Younger Adults.

To confirm the results reported in Section 7.5.2, that suicides were significantly higher in Glasgow than in the Highlands, all younger suicides were modelled against areatype. Table 7-7 shows the results from model 1, in which younger adult suicides was the dependent variable, and areatype was the independent variable. Table 7-6 showed that the areatype variable categorised the CATT2s into one of four areas: the Highlands; Glasgow; Other Cities; and All Other Areas. Table 7-7 reports the results in relation to the Highlands, which was the base category, and therefore confirms that suicide among younger adults is higher in Glasgow than in the Highlands, controlling for population. In addition, the coefficients suggest that fewer suicides occurred in Other Cities and All Other Areas, although the result for the Other Cities was not significantly different to the Highlands and Islands. As expected, the results from model 1 correspond with the SMRs reported for younger adult suicides across these four areas (Figure 7-4).

```
Poisson regression                                Number of obs   =      30172
                                                  LR chi2(3)      =     184.58
                                                  Prob > chi2     =     0.0000
Log likelihood = -10357.431                       Pseudo R2       =     0.0088
```

Total Suicide	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Glasgow	**.3272797**	**.0700329**	**4.67**	**0.000**	**.1900177**	**.4645418**
Other Cities	-.0578884	.0710722	-0.81	0.415	-.1971873	.0814105
Other Areas	**-.2721412**	**.0636539**	**-4.28**	**0.000**	**-.3969005**	**-.1473819**
_cons	-7.348307	.059655	-123.18	0.000	-7.465229	-7.231386
logTotPop	(offset)					

Table 7-7 Results from Poisson model 1: Younger adult suicide by areatype (significant results in bold)

However, Table 7-8 shows that the social factors explain the higher incidence of suicide in Glasgow. Furthermore, Table 7-8 demonstrates that when social conditions are controlled for, suicide among younger adults is significantly higher in the Highlands and Islands than anywhere else. The coefficient for Glasgow remained significant but changed signs, indicating that suicide among younger adults was higher in the Highlands and Islands than in Glasgow, when social conditions were controlled for. In addition, the model shows that suicide was significantly lower in the Other Cities and All Other Areas than in the Highlands. Of the social variables used in the model (Table 7-8), the unemployment variable had the most explanatory power, with a coefficient of 0.0221355 ($p=0.000$).

One unexpected finding was that the migration variable (%migration) was negatively associated with suicide among younger adults, with a coefficient of –0.0099645. Other researchers (e.g. Dorling and Gunnell 2003) have shown strong positive relationships between the proportion of migration and suicide. The results in Table 7-8 might be explained by three factors. First, the %migration variable quantified the proportion of in-migration regardless of the distance travelled, and a more appropriate measure might be to consider the role of long distance migrant flows. Second, the relative weakness of the migration variable might be an artefact of geographic scale. Third, the migration variable used here might not be a good surrogate for the effect that is being tested (i.e. population turnover).

Another unexpected result was that the variable representing overcrowding (%crowdHouses) demonstrated a negative association with suicide risk, although the coefficient was weak, but very significant -0.0083266, $p=0.001$). This was unexpected since overcrowding was one of the variables used to construct the Carstairs index of deprivation. On the other hand, it could be argued that the overcrowding variable had a protective effect on suicidal tendencies, and that individuals at risk of suicide felt more included and thus less isolated than if they were living alone. A second variable used in the Carstairs index (%LowSocClass) also yielded a slightly surprising result, whereby the direction of the coefficient was positive (as expected), but not significant. Contrary to the literature, the proportion of single persons in an area (%singlePerson) did not exhibit a significant influence on suicide risk. Rather, Table 7-8 shows a very weak coefficient (0.0033389), which was not quite significant ($p=0.078$).

Poisson regression

	Number of obs	=	30120
	LR chi2(13)	=	926.48
	Prob > chi2	=	0.0000
Log likelihood = -9981.7867	Pseudo R2	=	0.0444

Total Suicide	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1991	.0469974	.0664637	0.71	0.479	-.0832691	.177264
2001	**.4862479**	**.0818216**	**5.94**	**0.000**	**.3258805**	**.6466153**
Glasgow	**-.2401612**	**.081711**	**-2.94**	**0.003**	**-.4003119**	**-.0800106**
Other Cities	**-.2287307**	**.0766879**	**-2.98**	**0.003**	**-.3790362**	**-.0784253**
Other Areas	**-.3516545**	**.0646848**	**-5.44**	**0.000**	**-.4784343**	**-.2248747**
%unemployed	**.0221355**	**.0030925**	**7.16**	**0.000**	**.0160744**	**.0281967**
%migration	**-.0099645**	**.0026485**	**-3.76**	**0.000**	**-.0151554**	**-.0047736**
%notowncar	**.0072103**	**.0020157**	**3.58**	**0.000**	**.0032596**	**.011161**
%crowdHouses	**-.0083266**	**.0026146**	**-3.18**	**0.001**	**-.0134511**	**-.003202**
%lowSocClass	.0023172	.0014557	1.59	0.111	-.000536	.0051704
%1persnHouse	**.0068204**	**.0017036**	**4.00**	**0.000**	**.0034814**	**.0101594**
%rentedAccom	**.002867**	**.0010959**	**2.62**	**0.009**	**.000719**	**.005015**
%singlePerson	.0033389	.001894	1.76	0.078	-.0003733	.0070512
_cons	-8.263481	.108896	-75.88	0.000	-8.476913	-8.050048
LogPop(15-44)	(offset)					

Table 7-8 Results from Poisson model 2: Younger adult suicide by social factors (significant results in bold)

7.7.4. Modelling Suicide Risk – Younger Males

Since male suicides have increased significantly during the 20 years under investigation, the analyses in the previous Section were replicated for males. The results of model 3, which estimates the occurrence of suicide among younger males by areatype, are shown in Table 7-9. The major difference between the results for all younger adults (Table 7-7) and younger males (Table 7-9) is that the coefficient reported for males in Other Cities is stronger (-0.1558759) and significant (p=0.047). In addition, the coefficient reported for younger males in Glasgow was weaker (0.2446945) than for all younger adults (0.3272797, p=0.000). Nonetheless, the same broad conclusion that suicide was significantly higher in Glasgow than in the Highlands and Islands remained.

```
Poisson regression                                Number of obs   =      30170
                                                  LR chi2(3)      =     141.43
                                                  Prob > chi2     =     0.0000
Log likelihood = -8612.3873                       Pseudo R2       =     0.0081
```

male suicide	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Glasgow	**.2446945**	**.0772852**	**3.17**	**0.002**	**.0932182**	**.3961708**
Other Cities	**-.1558759**	**.0785884**	**-1.98**	**0.047**	**-.3099063**	**-.0018455**
Other Areas	**-.3480764**	**.0694839**	**-5.01**	**0.000**	**-.4842624**	**-.2118904**
_cons	-6.844082	.0646846	-105.81	0.000	-6.970861	-6.717302
logMalePop	(offset)					

Table 7-9 Results from Poisson model 3: Younger male suicide by areatype (significant results in bold)

However, as with younger adults, when social conditions are taken into account (model 4, Table 7-10), it is apparent that the occurrence of suicide among younger males is higher in the Highlands and Islands than Glasgow. Moreover, since the coefficient reported for each areatype is considerably stronger for younger males (Table 7-10) than for younger adults (Table 7-8), one would expect that the suicide risk in the Highlands and Islands would be higher for younger males than younger adults. Indeed, the coefficients for the unemployment (%unemployed), migration (%migration), and lack of car ownership (%notowncar) are also stronger for males than for younger adults. In contrast, the respective effects of crowding (%crowdHouses), renting (%rentedAccom) and single occupancy (%1perHhold) were weaker for males than for all younger adults.

The proportion of residents whose occupations were categorised as Social Class IV or Social Class V (%lowSocClass), and the proportion of single residents (%SinglePerson) were the only two variables considered that were not significantly associated with suicide among younger males. In addition, whereas the number of suicides in 1991 was not significantly higher than in 1981 among younger adults (Table 7-8), suicide among younger males were significantly higher (p=0.033) in 1991 than in 1981.

```
Poisson regression                                Number of obs   =      30118
                                                  LR chi2(13)     =     762.82
                                                  Prob > chi2     =     0.0000
Log likelihood = -8297.0258                       Pseudo R2       =     0.0439
```

MaleSuicide	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1991	**.164268**	**.0769769**	**2.13**	**0.033**	**.0133961**	**.31514**
2001	**.6646185**	**.0948627**	**7.01**	**0.000**	**.478691**	**.8505461**
Glasgow	**-.3239349**	**.091131**	**-3.55**	**0.000**	**-.5025483**	**-.1453215**
Other Cities	**-.3099208**	**.0851314**	**-3.64**	**0.000**	**-.4767752**	**-.1430664**
Other Areas	**-.4385972**	**.0707645**	**-6.20**	**0.000**	**-.5772931**	**-.2999013**
%tunemployed	**.0233801**	**.0035007**	**6.68**	**0.000**	**.0165189**	**.0302414**
%migration	**-.0121778**	**.0030722**	**-3.96**	**0.000**	**-.0181993**	**-.0061564**
%notowncar	**.007845**	**.0023091**	**3.40**	**0.001**	**.0033193**	**.0123707**
%crowdHouses	**-.0080368**	**.0030285**	**-2.65**	**0.008**	**-.0139727**	**-.002101**
%lowSocClass	.0025032	.0016536	1.51	0.130	-.0007378	.0057442
%1perHhold	**.0062657**	**.0019412**	**3.23**	**0.001**	**.002461**	**.0100703**
%rentedAccom	**.0027362**	**.0012581**	**2.17**	**0.030**	**.0002704**	**.0052021**
%singlePerson	.001417	.0021681	0.65	0.513	-.0028324	.0056664
_cons	-7.756496	.1239904	-62.56	0.000	-7.999513	-7.51348
logMalePop	(offset)					

Table 7-10 Results from Poisson model 4: Younger male suicides by social factors (significant results in bold)

The model above suggested that the social factors included in model 4 explained the distribution of suicide reasonably well, except in the Highlands. This suggested that factors that were not considered in the model, such as psychiatric illness and geographic isolation, might influence suicidal behaviour in the Highlands. Philo and Parr (2004) reported that mental health problems are increasing in the Highlands, and that the increase was due in part to migrants moving from urban areas into the Highlands and Islands with existing mental health problems. While the proportion of residents with poor mental health in the Highlands and Islands might be lower than in urban areas, access to appropriate services is often restricted in remote areas (Stark *et al.* 2004).

7.7.5. Modelling Suicide Risk – Younger Females

While suicide among younger males increased over time, the incidence of suicide among younger females declined. This Section uses the same two models used previously in this Section to determine the extent to which social factors explain suicide among younger females in Scotland.

Table 7-11 shows the output from model 5, in which female suicide was modelled against areatype. As for younger males and all younger adults, suicide occurrence was significantly higher in Glasgow than the Highlands and Islands for younger females, with a coefficient of (0.7915457, p=0.000). However, unlike for younger males (Table 7-9) for whom suicide was significantly lower in Other Cities than the Highlands, Table 7-11 reports a significant and positive coefficient (0.4299302, p=0.013) for younger females. Thus, controlling for population, suicide risk among younger females was significantly higher in urban areas than rural environments. Similarly, the results for younger adults (Table 7-7) and younger males (Table 7-9) showed negative (and significant) coefficients for suicide incidence in the residual area group (All Other Areas). However a positive coefficient was reported for younger females in Table 7-11, although it was not significantly different to the base category.

Poisson regression	Number of obs	=	30171
	LR chi2(3)	=	56.56
	Prob > chi2	=	0.0000
Log likelihood = -3626.6572	Pseudo R2	=	0.0077

Female suic.	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Glasgow	**.7915457**	**.1710097**	**4.63**	**0.000**	**.4563729**	**1.126719**
Other Cities	**.4299302**	**.1725164**	**2.49**	**0.013**	**.0918043**	**.7680561**
Other Areas	.1472652	.1609807	0.91	0.360	-.1682512	.4627816
_cons	-8.528043	.1543033	-55.27	0.000	-8.830472	-8.225614
LogFemalePop	(offset)					

Table 7-11 Results from Poisson model 5: Younger female suicide by areatype (significant results in bold)

The social factors defined in Table 7-6 were included in the model of suicide among younger females (model 6, Table 7-12) and indicated that, unlike for younger adults and younger males, suicide incidence among younger females was higher in Glasgow than the Highlands, but not significantly, having controlled for these social variables. Moreover, whereas for adults (Table 7-8) and males (Table 7-10) the coefficients for Glasgow, Other Cities and All Other Areas were significant and negative, for younger females the coefficients for these areas were positive, but were no longer significant. Therefore, these results suggested that the model for younger females explained much of the suicide risk in Glasgow.

While the majority of the social variables used to predict suicide were significant for adults and males, this was not true for females. For example, for younger males the coefficients for suicide in wave 2 (1991) and wave 3 (2001) were positive and significant, suggesting that the suicide incidence increased significantly over time. However for younger females, Table 7-12 shows that only suicide in 1991 was negative and significant (-0.2668547, p=0.045). Furthermore, the coefficient for female suicide in 1991 was the strongest of the significant variables included in model 6.

Once again, the unemployment variable (%unemployed) was based on the proportion of the total population unemployed, rather than the total number of females. As expected, the unemployment variable was positively associated with suicide risk among younger females (0.0156974), and was the most significant of the social variables included in model 6 (p=0.015). The only other variables that played a significant role in the predication of female suicide were the proportion of the population that did not own a car (%notowncar, 0. 0095569, p=0.020) and the overcrowding variable (%crowdHouses, -0.0120157, p=0.021). The lack of car is often considered to be a surrogate for income, but in rural areas access to private transport is a necessity. In isolated areas, it could be postulated that car ownership is also a surrogate measure of social cohesion, as mobile individuals have a greater ability to maintain contact with distant neighbours and community members, thus reducing a feeling of isolation. Similarly, overcrowding is typically considered to be an indicator of relative deprivation, but vulnerable individuals who are at risk of attempting or completing suicide may benefit from the additional support and social interaction that is associated with a crowded living environment.

Thus the results from Table 7-12 suggest that younger females at risk of committing suicide do not appear to be affected by the proportion of single residents; the proportion of single occupant households; or in areas which have a high proportion of population turnover. However, there are a number of individual factors (e.g. depression, drug use, mental health problems) that could not be included in the models, which could adversely affect suicidal females.

Poisson regression Number of obs = 30119
LR chi2(13) = 224.24
Prob > chi2 = 0.0000
Log likelihood = -3542.5099 Pseudo R2 = 0.0307

FemaleSuicide	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1991	**-.2668547**	**.1328687**	**-2.01**	**0.045**	**-.5272725**	**-.0064369**
2001	.0944175	.1627105	0.58	0.562	-.2244892	.4133242
Glasgow	.171839	.191377	0.90	0.369	-.2032531	.5469311
Other Cities	.1750189	.1826857	0.96	0.338	-.1830384	.5330763
Other Areas	.0651501	.1624462	0.40	0.688	-.2532386	.3835388
%tunemployed	**.0156974**	**.0064515**	**2.43**	**0.015**	**.0030527**	**.0283421**
%migration	-.0052414	.0051551	-1.02	0.309	-.0153452	.0048624
%notowncar	**.0095569**	**.0041166**	**2.32**	**0.020**	**.0014885**	**.0176253**
%crowdHouses	**-.0120157**	**.0051891**	**-2.32**	**0.021**	**-.0221862**	**-.0018453**
%lowSocClass	.0014221	.0030482	0.47	0.641	-.0045522	.0073963
%1perHhold	.0047896	.0035463	1.35	0.177	-.002161	.0117401
%rentedAccom	.0038875	.0022233	1.75	0.080	-.0004701	.0082452
%singlePerson	.0072933	.0038453	1.90	0.058	-.0002434	.01483
_cons	-9.382103	.2370489	-39.58	0.000	-9.84671	-8.917496
logFemalePop	(offset)					

Table 7-12 Results from Poisson model 6: Younger female suicide by area type, controlling for social factors (significant results in bold)

7.7.6. Summary

To summarise, this Section has shown that for younger adults (15-44 years) (Section 7.7.3) and younger males (Section 7.7.4), the higher incidence of suicide found in Glasgow compared to elsewhere could be explained by social conditions. However, the social conditions used in these models could not explain the suicide risk in the Highlands and Islands. The results for younger females (Section 7.7.5) showed that no difference was found between any of the four areas once social conditions were accounted for.

7.8. Discussion

This chapter has explored the changing inequalities of suicide in Scotland, and extended the preliminary findings of Chapter Five. Five key questions have been examined, based on evidence from the literature, which was reviewed in the first three Sections of this chapter. The first question examined whether suicide increased among the younger adults and decreased among the older population between 1980-1982 ('1981') and 1999-2001 (2001). Moreover, this question was extended to determine how the *suicide gap* had changed over time. Mortality ratios were calculated for period specific deprivation quintiles, standardised to the 1981 death rate (i.e. 2001_{81} in previous Chapters).

In agreement with McLoone (1996) and Gunnell *et al.* (2003), the analysis in Section 7.4 showed that suicide among younger adults (aged between 15 and 44 years) increased over time while concurrently decreasing among older adults (45+). The analysis in Section 7.4 indicated that suicide inequalities widened among the younger and the older populations. More importantly, the analysis showed that in spite of suicides declining over time for females, inequalities widened most for females between 1981 and 2001. The widening gap in suicides among younger females was due in part to all quintiles except the most deprived quintile demonstrating reductions in suicide between 1981 and 2001. For older adults, the occurrence of suicide reduced between 1981 and 2001, although in 2001 suicide was still considerably higher in the most deprived areas, which also resulted in widening suicide inequalities. For older females, suicide in deprived areas was 1.70 times more prevalent than for females in the least deprived areas in 2001, a relative reduction of 10% since 1981. Older males also experienced a reduction in inequalities, although the improvement was relatively lower than for females (4%), and inequalities between the most and least deprived areas remained at 1.88 in 2001.

The *Choose Life* Report (The Scottish Executive 2002b) recognised that younger people were more vulnerable and at risk of suicide, which is coincident with the results shown in Section 7.4, and the results emphasize that younger males were particularly vulnerable. Furthermore, the results in Section 7.4 highlighted that policies and actions aimed at reducing suicide among younger females should also be established.

There was some evidence in the literature to suggest that suicide rates were higher in the Highlands and Islands than other parts of Scotland (e.g. Crombie 1991; Stark *et al.*. 2002), therefore Section 7.5 examined whether this was indeed the case for 1981 and 2001. Each CATT2 zone was allocated to a 2001 Council Area, and categorised further into one of four area types: Highlands and Islands (including Argyll & Bute, Orkney Islands, Shetland Islands, and Eilean Siar), Glasgow City, Other Cities (Aberdeen, Dundee, Edinburgh), and All Other Areas, and SMRs were calculated based on the 1981 death rate.

The results showed that the suicide rate was consistently higher in Glasgow than the Highlands, for younger and older age groups. With regard to the existing literature, the observation that suicides were decreasing in younger adults and increasing for older adults was in agreement with others such as Dorling and Gunnell (2003). However, the results here suggested that suicide was more prevalent in Glasgow than the Highlands, which was in contrast to Crombie (1991) and Stark *et al.* (2002), although each study has used data from different time periods. In addition, the observation that Glasgow had higher rates than the Highlands and Islands indicated that suicides were associated more with urban settings than rural environments, which differed from the conclusions of Middleton *et al.* (2003) who found that suicide risk among the population aged between 15 and 44 increased with remoteness from major urban centres.

The third question explored in this chapter was whether the widening suicide gap varied geographically. It was thought that socio-economic deprivation might explain the differences between Glasgow and the Highlands. However, as suicide is relatively rare in Scotland, accounting for approximately 600 deaths per annum, deprivation was treated as a dichotomous variable. Quintiles 1, 2 and 3 were merged to create the *low deprivation* category, while quintiles 4 and 5 combined to create the *high deprivation* category, and SMRs were calculated for the 1981 and 2001 period by deprivation and area type. As one might expect, the SMRs were higher in the high deprivation category than in the low deprivation category in all age and gender groups. Glasgow had higher SMRs than the Highlands and Islands among younger adults and younger females, but the SMR for the Highlands and Islands was slightly (but not significantly) higher than Glasgow among younger males.

SMRs were significantly larger in the high deprivation category compared with the low deprivation category in the *same* area, but the differences *between* areas were not always significant. For example, among younger males in Glasgow, the SMR for the low deprivation category in 1981 was significantly lower than the SMR for the high deprivation category in Glasgow. However, the SMR for the low deprivation category in Glasgow for 1981 was not significantly different to the SMRs for the low deprivation category in the Highlands, Other Cities or All Other Areas.

Table 7-5 demonstrated the nature of widening inequalities in the four areas, for suicides across all ages, younger adults (15-44) and older adults (45+), and revealed a number of interesting findings. First, between 1981 and 2001 across all ages, inequalities in Glasgow were relatively stable for males, but increased for females. In the Highlands and Islands the converse was observed: inequalities among all males increased marginally (1.06), while females improved by 12% over time. Second, among younger adults, relative improvements were observed in Glasgow while inequalities in the Highlands and Islands remained stable. However, among younger males inequalities in Glasgow improved by 19% but widened by 19% in the Highlands. In contrast, inequalities among younger females in Glasgow widened marginally, while a significant improvement occurred in the Highlands. Third, while inequalities in Glasgow narrowed for younger males, they widened for older males. Similarly the widening inequalities among younger males in the Highlands and Islands were contrasted by a 10% reduction among older males.

Perhaps one surprise from Table 7-5 was the relative stability, and in some cases improvement, of the inequalities in Glasgow. Particularly when one reflects on the findings of Watt and Ecob (1992) and Shaw *et al.* (1999) among others, that Glasgow has a significantly worse health experience than average. However, relative inequalities in Glasgow were on average 1.40 times higher than for the Highlands and Islands for all adults in 1981 and 2001. For males, the ratio was 1.34 times higher than in the Highlands, while among females, inequalities in Glasgow were on average 1.85 times higher than in the Highlands. Thus, the results in Table 7-5 should be interpreted with caution, since Glasgow continued to have considerably higher inequalities than the Highlands and Islands in 2001.

The fourth substantive aspect of the geography of suicide was whether clusters of suicide existed among younger males, females and adults (15-44). Durkheim (1897) noted that suicide tended to cluster in large urban settlements and capital cities, and that the intensity of the cluster decreased inversely with distance from the core. However, this inherently spatial assumption has been left relatively unexamined by geographers. Rather, the medical community (mainly psychiatrists) have used anecdotal evidence to explore the possibility that suicides cluster in time and space. Joiner (1999) distinguished between point clusters (e.g. Haw 1994, Wilkie *et al.* 1998), in which two or more suicides occur proximal to each other spatially, and mass clusters, which are temporal in nature and often (but not always) associated with the death of a celebrity (Hawton *et al.* 2000), or the (insensitive, or explicitly descriptive) reporting of a suicide in the media (Gunnell and Frankel 1994).

Therefore, Section 7.6 examined the spatial clustering of suicide in Scotland, and used all 10,058 CATT2s as separate entities for the first time. Significant clusters were found in the 1981, 1991, 2001, and 1981-2001 (see Figure 7-6-Figure 7-17) for younger males and females (separately and combined). With the exception of one small cluster located in Midlothian, all of the statistically significant clusters ($p<0.05$) were located in Glasgow. However, it should be appreciated that while the centre of each cluster was located in Glasgow City, some clusters sprawled into neighbouring Council Areas (Figure 7-18).

A number of social and behavioural factors have been shown to be associated with elevated suicide risk. These factors included unemployment, alcohol and other drug misuse and social deprivation. Shaw *et al.* (1999) demonstrated that some parts of Glasgow suffered the most extreme types of poverty (e.g. unemployment, overcrowding) and multiple types of disadvantage (e.g. lack of education,) across Britain. Similarly, PHIS (2004) showed that a high proportion of males and females in Glasgow consume more than the recommended weekly alcohol limit, and some Parliamentary Constituencies have high proportions of income support claimants, and drug-related mortality. Pacione (2004) also demonstrated the extent of deprivation Glasgow has experienced since 1971. In particular, he showed that while a handful of the most deprived areas in Glasgow at the time of the 1971 census have since disappeared, in a large majority of areas within Glasgow, deprivation has either persisted or intensified through to 2001. The most recent official report of drug-related deaths in Scotland (GROS 2004) suggested that 34% of these deaths occurred in the Greater Glasgow Health Board during 2003. In contrast only 2% of drug related deaths were observed in the Highland Health Board. These trends have been reasonably stable since 1996.

Thus, it could be argued that given these higher rates of social factors associated with suicide, the observation that suicides cluster in Glasgow could be expected. Yet, the *Choose Life* report (The Scottish Executive 2002b) failed to recognise the elevated risk of suicide among younger people in Glasgow. While *Choose Life* identified vulnerable *individuals* (children, young people, substance abusers), one could argue that an explicit area based strategy might be complementary and ensure that as many individuals at risk as possible are provided with the appropriate resources to help reduce the national suicide rate by 20%.

The final question examined in this chapter was the extent to which social factors can explain the patterns of suicide among younger adults (15-44) within CATT2s between 1981 and 2001 (Section 7.7). The social variables were derived from the 1981, 1991 and 2001 censuses, and each of the variables used in the model had been shown to be associated with suicide in the literature.

Two separate models were fitted for younger males, females and adults (15-44), in which the Highlands and Islands was the reference group. The first model simply predicted the number of suicides based on the area types (as defined in Section 7.5). For younger adults, males and females, the coefficients for Glasgow were significantly higher than the Highlands and Islands ($p<0.006$ in all models). For younger males, suicide risk was significantly lower in Other Cities and All Other Areas than in the Highlands, while the suicide risk was significantly higher in Other Cities among younger females. The results suggested that for all gender groups, the suicide rate in Glasgow is significantly higher than the Highlands and Islands and confirmed the results from Section 7.5.

The results from the second model indicated that the when social conditions were controlled for, suicide among younger adults and younger males in the Highlands and Islands was significantly *higher* than the other three area types. In contrast, the model showed that suicide among younger females in Glasgow, Other Cities and All Other Areas were not significantly different to the Highlands. These results suggested that the social factors that were controlled for in the model did not provide an adequate explanation of suicide among younger adults or younger males in the Highlands. More importantly, the results indicate that the other factors that influence suicidal tendencies in the Highlands and Islands had a greater effect on males than females. Hawton (1998) suggested that the increase in suicide among younger males resulted from societal pressures, and the reluctance to seek help and/or advice during times of crisis.

The results from the modelling (Section 7.7) therefore *did not* support the recently introduced suicide prevention strategy in Scotland (The Scottish Executive 2002b), which identified rural and isolated areas as the only geographically specific priority group. Rather, the modelling showed that suicide risk was highest in Glasgow, and that the elevated risk in Glasgow could be explained better by the social conditions used. Therefore, this suggested that measures to reduce suicide in deprived areas should also be a priority in the national strategy. Gardner and Peck (1996) reported that drug-use can be found throughout the Highlands, and that the use of injecting could be as high as in urban parts of Scotland, although recent official reports (GROS 2004c) implied that this might not be the case. Additionally, Philo and Parr (2004) reported that the population in the Highlands and Islands had increased by 3% during the 1990s and was largely due to net in-migration. Furthermore, Philo and Parr (2004) found that there was a significant mental health problem in the Highlands, and that many of the interviewees that had migrated to the Highlands did so because they perceived beneficial effects on their existing mental health problems. The findings by Gardner and Peck (1996) and Philo and Parr (2004) indicate that risks associated with suicide do exist in the Highlands and that unless better resources are provided to the appropriate services, the suicide rate in the Highlands could continue to increase into the future.

This Chapter has revealed that there are many interpretations of how the geography of suicide has changed between 1981 and 2001. Suicide inequalities have been shown to vary between younger and older populations, between genders and also geographically. In addition, this chapter has found that suicides appear to cluster (at least ecologically) in Glasgow, and were persistent over time for younger males, females and adults. The findings have a number of implications, and lead one to suggest that deprived areas should be equally as important as rural and isolated areas in strategies aimed to reduce the suicide rate in Scotland.

8. Conclusions

8.1. Introduction

In this study, a new set of geographical zones derived from the small area census zones have been created in order to examine inequalities at a relatively local scale. Individual mortality records from 1980-1982, 1990-1992, and 1999-2001 obtained from the General Register Office for Scotland (GROS) and census data from 1981, 1991 and 2001 were used to examine the extent to which mortality inequalities changed over time. This study is the first to carry out a detailed ecological analysis of mortality inequalities for small areas in Scotland over this period.

Mortality rates in Scotland are among the highest in Europe for some causes of death. Parts of Scotland have the worst mortality trends in the United Kingdom. There is also considerable variation in mortality rates reported in the least deprived and most deprived areas within Scotland. Existing studies that examine the mortality inequalities have been undertaken using large geographical areas, as these areas are less susceptible to boundary changes over time. However, large areas such as Health Boards mask smaller areas that have relatively higher or lower mortality.

In this Chapter, each of the four thesis objectives outlined in Chapter One are revisited, for which the key methods and results are outlined. Next, the policy implications of this study are discussed, before the limitations of the research and directions for future research are reported. The Chapter concludes with a summary of the key findings from the study.

8.2. Revisiting the Thesis Objectives

8.2.1. Constructing a consistent geography

The first goal of this thesis was to create a boundary file that would facilitate the comparison of health and social data between 1981 and 2001 reliably at a relatively local scale. This process is reported in Chapter Four. The most common approaches to creating a consistent geography involve the transformation of a set of 'source' zones to a set of 'target' zones. However, existing techniques (e.g. Bracken and Martin 1995; Simpson 2002; Martin *et al.* 2002) rely upon population estimation techniques to transform data from the source zones to the target zones, which consequently introduces a variable degree of error.

This research has overcome this problem through the creation of the Consistent Areas Through Time (CATTs) for Scotland. The basic rule for the construction of the CATTs was that each CATT should be created from one or more *whole* 1981 Enumeration Districts (EDs), 1991 Output Areas (OAs) or 2001 OAs. This was achieved by using a *merging* strategy, in which a source geography (e.g. 1991 OAs) was overlain upon a target geography (the 1981 EDs), and whenever a zone in the source geography overlapped more than one target zone, then the affected target zones were merged.

Postcodes were used to establish a consistent geography for 1981 and 1991 (known as SUPER EDs), but the distribution of postcodes in 2001 did not adequately represent the actual configuration of the 2001 OAs. To integrate the 2001 OAs, the 2001 postcodes were initially overlain upon the SUPER EDs to determine which zones needed to be merged. However, this did not work satisfactorily, as it was found that in some cases, because the 2001 postcode grid references were unevenly distributed and meant that in some cases, the 2001 OAs were not correctly allocated to the SUPER EDs.

Therefore, the 2001 OA polygons were overlain upon the SUPER ED polygons, which produced a number of spurious zones, some of which resulted from differences in digitising, while others resulted from deliberate boundary changes between 1981 and 2001. The GROS produced a report listing the number of residential households (from ADDRESS-POINT™) within each polygon, which was subsequently used to distinguish deliberate boundary changes from digitising errors.

Three different sets of CATTs were produced. First, all polygons that did not contain any residential buildings were eliminated to create the cleanest possible consistent geography, known as CATT0, which contained 5,741 unique zones.

However, many of the zones covered large areas and/or had large populations. The analysis was repeated and all polygons that contained less than two residential buildings were merged to create 8,588 CATT1 boundaries. The configuration of the CATT1s was superior to the CATT0 generation, but the population in some of the zones remained relatively large. Once again, the merging process was repeated after merging all polygons that contained less than three residential buildings to create 10,058 CATT2 zones. The 2001 population of the CATT2s ranged from 50 to 18,510, which was comparable to the distribution of 2001 Census Area Statistics (CAS) Sectors published by the GROS. In addition, the configuration of the CATT2s better resembled the configuration of urban and rural settlements throughout Scotland. Therefore, the CATT2s were used in the research, and are recommended for future spatio-temporal analyses in Scotland.

The creation of CATTs means that for the first time in Scotland, vital statistics and social data from the census can be reliably compared from 1981 to 2001. Aggregation from the small area census geographies (1981 EDs, 1991 OAs, or 2001 OAs) to CATT2s is possible through the use of Geographic Conversion Tables (GCTs), or lookup tables. Unlike for existing GCTs (e.g. Simpson 2002), data aggregated from the CATT GCTs do not undergo apportionment. Rather, data from small areas (e.g. EDs and OAs) are wholly aggregated into a CATT. Furthermore, additional GCTs were created to enable aggregation from the CATT2 level to many higher administrative units, such as Health Boards, Council Areas, Parliamentary Constituencies, Sectors and Wards in 2001, and 1991 Districts.

It could be argued that the use of the CATT2 rather than CATT0 generation of the CATTs is unreliable as the CATT2s were involved the merging of polygons that contained less than three residential buildings. Indeed, the CATT0 generation was a truly consistent geography, but did not retain rural settlements adequately. Conversely, the maximum displacement error inherent in any given CATT2 is two households, which is considerably more accurate than the displacement of two postcodes, which might have been the case if the CATTs constructed from postcodes were retained. In 2001, each OA in Scotland was required to have at least 20 households in order to preserve confidentiality; therefore the biggest displacement error in the CATTs was 10% of the number of households of any particular 2001 OA. However, there were only 102 instances (of a possible 42,604) in which a 2001 OA only contained 20 households.

8.2.2. Examining the widening mortality gap

The second thesis objective – to examine the extent to which mortality inequalities in Scotland had widened between 1981 and 2001 – was examined in Chapter Five. Mortality data for 1980-1982 ('1981') and 1999-2001 ('2001') were aggregated to the CATT2 zones, which were subsequently divided into population-weighted quintiles based on the Carstairs index of deprivation (Carstairs and Morris 1991).

Standardised Mortality Ratios (SMRs) were constructed for all cause mortality, accidents, stroke, heart disease, all cancers, respiratory disease and suicides. The SMRs were calculated for males and females, separately and combined, in five-year age bands for all deaths and for all deaths occurring below 65 years of age (premature mortality).

During the 1980-1982 period (referred to as '1981'), the mortality gap between the most deprived and least deprived areas was already apparent, at 1.46 for all cause mortality and ranging from 1.34 for stroke mortality to 2.03 for suicide across the total population and all ages. Premature mortality inequalities (<65 years) were more pronounced, with mortality in the most deprived areas 1.86 times greater than in the least deprived areas. In addition, cause specific mortality ranged between 1.55 for accidents and 3.15 for respiratory disease. The differentials in mortality were higher for males than for females. For example, the ratio of inequalities for all cause mortality inequalities among males across all ages was 1.51 compared with 1.41 for females. In addition, there was variation in the distribution of inequalities by gender. Among males across all ages, inequalities ranged from 1.33 for heart disease to 2.23 for suicide. In contrast, inequalities among females across all ages ranged from 1.18 for accident-related deaths to 1.73 each for respiratory disease and suicide. Cancer mortality demonstrated the narrowest premature mortality gap for females (1.38), while accidents were the least polarized for males at 1.55. However, respiratory disease exhibited the widest premature inequalities for males (3.14) and females (3.17) in 1981.

During the 1999-2001 period, mortality from all causes and all ages in the most deprived quintile was 1.58 times higher than the least deprived quintile. Relative inequalities were narrowest for stroke mortality at 1.13, while suicide exhibited the widest mortality gap at 2.82. Premature mortality from all causes was nearly 3 times higher in the most deprived areas (2.99), and inequalities for specific causes of death ranged from 1.92 for cancers to 5.33 for respiratory disease. Inequalities for all cause mortality were wider for males than for females, at 1.88 for all ages and 3.19 for premature mortality, compared with 1.36 and 2.68 respectively for females. For males across all ages, inequalities in mortality from specific causes ranged between 1.32 for stroke to 2.74 for suicide, while inequalities among females across all ages were distributed between 1.04 for stroke to 3.06 for suicide. In terms of premature mortality, cancer exhibited the least inequalities, at 2.17 for males and 1.68 for females. Premature inequalities were widest for respiratory disease at 5.46 for males, while for females, heart disease in the most deprived quintile was 5.22 times higher than in the least deprived quintile.

The extent to which the mortality gap widened or narrowed between 1981 and 2001 was assessed using two approaches. First, SMRs were constructed based on *period specific* deprivation quintiles, in which SMRs for 1981 and 2001 were calculated based on population weighted quintiles derived from the 1981 and 2001 Carstairs index of deprivation respectively. Second, *consistent quintiles* were constructed by grouping mortality and population data for 1981 and 2001 based on the deprivation quintiles for 2001, and then calculating SMRs for both time periods based on the death rates for 1981.

Inequalities based on period specific quintiles

The research found that when period specific quintiles were used, relative inequalities in mortality from all causes increased by 24% among males, but decreased by 4% for females. However, variations in the patterns of inequalities were reported for different causes of death. For example, relative inequalities in mortality from stroke and respiratory disease decreased among the total population, while relative inequalities from mortality as a result of accidents, cancers, suicide, heart disease and all other causes of death combined widened. The mortality gap generally widened more for males than for females, although variations in the extent to which inequalities for particular causes of death changed differed between the sexes.

Relative inequalities for premature mortality from all causes increased by 61% for the total population, but the increase was higher for males (71%) and lower for females (45%). However, while some causes of death experienced a reduction in relative inequalities across the whole population, there were no reductions in inequalities for premature mortality from specific causes of death. Rather, relative inequalities widened least for cancers among males, females and the total population below 65 years. The widest premature mortality gap was reported for heart disease for the total population and for all other causes combined among males, but suicide inequalities increased the most for females.

Inequalities based on consistent quintiles

While the preceding discussion outlined that inequalities had generally widened over time, the CATTs belonging to a particular deprivation quintile in 1981 might not necessarily be in the same quintile in 2001. Social and mortality data from 1981 and 2001 were grouped by the 2001 population weighted quintiles to ensure that CATTs were assigned to the same deprivation quintile for both time periods, thus producing consistent quintiles. By applying the 1981 death rates to the 2001 data, it was possible to determine the extent to which mortality had declined, while also examining the widening mortality gap.

The SMRs for 2001 were lower in the consistent quintile analysis, since the death rates from 1981 were used. However, for most causes of death, the relative inequalities reported for consistent quintiles were within ±8% of the relative inequalities reported for period specific quintiles. However, the relative inequalities in suicide were 1.62 times greater in 2001 than in 1981, whereas the period specific quintiles reported a relative increase in the suicide gap of 1.39. Similarly, whereas the premature suicide gap for the total population below 65 years had increased by 1.56 between 1981 and 2001 using period specific quintiles, the gap widened by 1.94 times using consistent quintiles. Gender specific inequalities were also marginally affected when consistent quintiles were used to quantify the mortality gap in Scotland, although results for males were more sensitive than the results for females.

The broad conclusions from these analyses were that relative inequalities between the least deprived and most deprived areas in Scotland worsened for males and females (separately and combined), and for each cause of death studied, regardless of how the deprivation quintiles were constructed. Furthermore, the results suggested that, for the minority of causes, inequalities in mortality in later life were narrowing, particularly for older females.

Social mobility of CATTs

The use of consistent quintiles ensured that the same CATTs belonged to each quintile in 1981 and 2001. However, it was likely that some areas had become either more or less deprived over time. Because the CATTs were consistent through time, it was possible to construct 'social mobility groups', based on the changing deprivation profiles of the CATTs. Seven social mobility groups were chosen to examine the relationship between changing deprivation profiles and the subsequent changes in mortality, rather than an assessment of the widening mortality gap. Three groups contained CATTs that belonged to quintiles that did not change over time, two categories represented those CATTs whose relative deprivation worsened over time; and two groups comprised of CATTs whose relative deprivation improved between 1981 and 2001.

SMRs were calculated for deaths from all causes across the total population and for premature mortality in 1981 and 2001, based on the 1981 death rates, for each social mobility group. The results in Section 5.7 showed that CATTs that were in the least deprived quintile in 1981 and 2001 had the lowest SMRs, while the CATTs in the most deprived quintile in both periods exhibited the highest SMRs. Additionally, the social mobility groups representing worsening deprivation over time had higher mortality than those categories containing CATTs that became less relatively deprived over time. Furthermore, the social mobility gradient was more apparent for premature mortality than for all age mortality.

In conclusion, these analyses showed that areas that became relatively less deprived over time places also experienced improvements in health. It should be emphasised that these improvements, which may have resulted from policy interventions or through other social processes, could not be identified without the use of a consistent geography. Furthermore, it could be suggested that policies such as Social Inclusion Partnerships, which are designed to improve the health and well being of residents in very deprived areas, may be having a positive effect that is not normally observed in conventional quintile-based analyses. However, further research is required to determine whether all areas experiencing upward social mobility are improving due to policy interventions, or whether other social processes are improving areas.

8.2.3. The relationship between population change and mortality

The third thesis objective was to examine the relationship between population change and mortality, and was discussed in Chapter Six. Contemporary studies from Northern Ireland (O'Reilly 1994; O'Reilly and Stevenson 2003), the UK (Davey Smith *et al.* 1998b; 2001c), Sweden (Molarius and Janson 2000), Spain (Regidor *et al.* 2002) and Scotland (Boyle *et al.* 2004a) have all indicated that areas suffering the most population decline also experience the highest mortality rates, and that the relationship is stronger for males than females. The most common explanation for the existence of this relationship is the 'healthy migrant effect', in which people in good health are more likely to have the ability to leave places with unfavourable social conditions than those with poor health.

This study made two contributions to the population change and mortality literature. First, the relationship was examined across four different spatial aggregations. Second, the study examined the role of relative deprivation on the relationship between population change and mortality. The relationship was examined for premature mortality from all causes, accidents, stroke, heart disease, cancers, respiratory disease, suicides and all other causes of death combined. The four geographic scales observed were pseudo Health Boards (15 zones), Council Areas (32 zones), Districts (56 zones) and Parliamentary Constituencies (73 zones). Pearson correlations weighted by population size were calculated for each cause of death and population change.

The negative association between population change and mortality followed a linear trend for most causes of death, with the correlations weakening as the number of zones increased. However, suicides for all persons, males, and females, and respiratory disease among females were exceptions, whereby the Council Area correlations were higher than those reported for the Health Board. Accident mortality demonstrated neither a consistent relationship nor a strong relationship with population change.

In the existing literature, the relationship between population change and mortality was stronger for males than for females. However this was not always the case in this study. For Parliamentary Constituencies, premature female mortality from all causes exhibited the strongest relationship with population change. Moreover, the associations for female mortality were stronger than for males for most causes of death, and at most geographic scales.

To determine whether declining areas had higher mortality, the CATT2s were allocated to a population change category (decline, stable and growth), according to the extent of population change between 1981 and 2001. SMRs for premature mortality from all causes were calculated for males, females and the total population, by population change category. In agreement with existing literature, mortality was highest in the declining areas, and was significantly higher than the mortality in the stable areas. In addition, mortality in the stable areas was significantly higher than in areas experiencing population growth.

The influence that deprivation had on the association between population change and mortality was assessed by assigning each CATT2 to a population weighted deprivation quintile for 2001, and subsequently reapportioning to a population change category. Therefore, there were 15 deprivation/population change categories. The analysis demonstrated that the areas with declining populations did not have higher mortality than those areas whose populations grew between 1981 and 2001. Rather, the SMR for the declining population category was only significantly higher than stable or growth areas in quintile 2. A social gradient of mortality existed, in which the least deprived quintile had the lowest SMR, which increased for each subsequent quintile. However, in the most deprived quintile for all persons and for males, premature mortality was significantly higher for areas experiencing population growth. Therefore, these results suggested that the relationship between population change and mortality was an artefact of deprivation-related social circumstances.

It should be emphasised that the influences that geographic scale and deprivation have on the relationship between population change and mortality could only be investigated properly because the CATTs were consistent through time. Furthermore, the results reported in Chapter Six concur with current resource allocation practices in Scotland, which apportion resources according to deprivation rather than population change.

8.2.4. The changing pattern of suicide in Scotland 1981-2001

The final objective of this thesis was to examine the widening inequalities for suicide between 1981 and 2001, and was discussed in Chapter Seven. Suicide was selected for more detailed analyses because inequalities reported for suicide across the total population and for premature mortality were consistently among the widest of the causes of death examined in this research. Recent research from the United Kingdom (e.g. Charlton *et al.* 1992; Gunnell *et al.* 2003; Dorling and Gunnell 2003) has suggested that suicide has been declining among older adults, but increasing among younger adults, particularly among males. In addition, a recent study (Stark *et al.* 2002) reported that suicide was higher in the Highlands than in other parts of Scotland. A further motivation to examine the suicide gap in Scotland was that the national suicide prevention strategy, *Choose Life* (The Scottish Executive 2002b), only identified isolated and rural areas as a priority group.

Four questions were examined to assess the widening suicide gap. First, the social gradient in suicide was examined for the total population as well as 'younger adults' defined as the population aged between 15 and 44 years, and 'older adults', which comprised of the population aged 45 years and over. Second, suicide was examined by grouping the CATT2s into four area types: the Highlands and Islands, Glasgow, Other Cities, and All Other Areas, to determine whether suicide was an urban or rural problem. Third, data for individual CATTs were used to identify spatial clusters of suicide. Fourth, the CATTs were used to statistically model the occurrence of suicide to determine whether suicide incidence was higher in urban or rural areas, before and after social conditions had been controlled for.

The suicide social gradient was examined by calculating SMRs for 1981 based on the 1981 deprivation quintiles, and for 2001 based on the 2001 quintiles but standardised to the 1981 death rates. Absolute and relative inequalities were calculated for males, females and all adults, for all ages, as well as the population aged between 15 and 44 (younger adults) and the population aged 45 and over (older population). Between 1981 and 2001, the reported number of suicides increased among younger adults, but decreased among the older population. However, inequalities widened for all age groups, regardless of whether males and females were examined separately or combined. Although female suicides accounted for 37% and 25% of all suicides in 1981 and 2001 respectively, inequalities widened the most among females in each of the three age groups studied. Relative inequalities among younger females widened from 2.96 in 1981 to 5.77 in 2001, a relative increase of 1.95. In contrast inequalities among younger males grew from 2.99 in 1981 to 3.67 in 2001, a relative increase of 1.23.

The CATT2s were grouped into four area types in order to ascertain whether suicide was highest in Glasgow, the Highlands and Islands, Other Cities (Aberdeen, Dundee and Edinburgh), or in All Other Areas. Between 1981 and 2001 suicides among younger adults and younger males increased significantly in each of the four areas. Conversely, among older adults suicides declined significantly in Glasgow, Other Cities and All Other Areas, while all four areas declined significantly for older females. It was concluded that that Glasgow had significantly higher mortality than the Highlands and Islands for all younger adults, and for younger females, but not for younger males, or for the older age groups.

Since the occurrence of suicide was relatively rare, the numbers were too small to calculate reliable SMRs for each area type by deprivation quintile, so a dichotomous variable was constructed. Suicides that occurred in quintile 1 and quintile 2 were combined to create the 'low deprivation' category, while quintiles 3, 4 and 5 were combined to create a 'high deprivation' category. As expected, suicide was consistently higher in 'high deprivation' group, regardless of the age group or gender of interest. However, the difference between the SMRs for the high and low deprivation categories was not always significant. For example, the Highlands only reported significant differences for the total population in 2001 and younger adults in 2001. This analysis led to the conclusion that the occurrence of suicide in Glasgow was not significantly different to the Highlands, Other Cities or All Other Areas, once deprivation was controlled for.

All of the conclusions reported thus far have involved aggregating the CATTs into other groups, such as deprivation quintiles or area types. The cluster analysis was the first analysis presented in the thesis that used all 10,058 CATT2s as separate entities to explore patterns of mortality in Scotland. More specifically, CATT2s were used to identify spatial clusters of suicide among males and females (separately and combined) aged between 15 and 44 years. Spatial clusters were sought for males, females and all adults aged between 15 and 44, for 1981, 1991, 2001 and 1981-2001. Surprisingly, all of the statistically significant clusters identified were located in Glasgow, except for one relatively small cluster, which was located in Midlothian during 1991. The suicide clusters were located in East Glasgow, and included some of the most deprived parliamentary constituencies in Britain, such as Glasgow Shettleston, Glasgow Springburn and Glasgow Kelvin.

The final research question, in relation to suicide, was to statistically model suicide among the younger population. Once again, the CATT2s were treated as separate entities, and two Poisson models were fitted each for all younger adults, younger males and younger females. The first model predicted suicide risk after controlling for the area type, while the second model predicted suicide risk once a number of social conditions shown to be associated with suicide had been controlled for. The results from the first model indicated that suicide risk was higher in Glasgow than the Highlands for younger adults, younger males and younger females. In contrast, the second model demonstrated that the suicide risk was significantly higher in the Highlands than the other three areas for younger adults and younger males, but not younger females, once social conditions were controlled for.

8.3. Policy Implications of the Thesis

The CATTs are consistent through time and it was therefore possible to examine the changing configuration of society in Scotland, with particular interest in the social patterning of mortality. A number of findings discussed throughout this study should be of particular interest to policy makers. First, any health and social data could be aggregated into CATTs to examine societal changes over a relatively long time period. Moreover, the configuration of the CATTs should be maintained for the 2011 census as a higher geography in Scotland, to provide another 'wave' of longitudinal data, but also to extend the longevity of a useful dataset.

Second, inequalities in premature mortality widened for males and females, regardless of the cause of death studied (Chapter Five). In the main, the gap has increased either because mortality rates are reducing at a slower rate in more deprived areas than in less deprived areas, or because mortality has increased in more deprived areas but declined in less deprived areas. The remarkable similarity in premature female inequalities suggests that a broad-spectrum approach is required to reducing health inequalities in Scotland. However, the inequalities in 2001 should also be taken into account when policy related to health inequalities are considered. For example, although the increases in relative inequalities for respiratory disease and stroke were similar, inequalities in respiratory disease were substantially higher in 2001 than for stroke related mortality.

Therefore, policies should be developed which focus on reducing health inequalities in more deprived parts of Scotland. Indeed, the analysis examining the social mobility of CATTs suggests that the creation of programmes such as Social Inclusion Partnerships and other initiatives derived from the Towards a Healthier Scotland White Paper (The Scottish Office 1999a) appear to be a step in the right direction.

Third, this research recognised that the association between population change and mortality was affected by geographic scale (Chapter Six). Thus, resource allocation models that apportion health-related resources based on population size may be less equitable in areas experiencing population decline. Furthermore, the degree of inequity would vary depending on the scale at which resources were distributed. The results therefore suggested that a more practicable approach would be to allocate resources based on the relative distribution of deprivation in an area. Indeed, the current resource allocation model implemented in Scotland is based on deprivation rather than population size. However, there is debate as to whether the definition of deprivation used in the formula is appropriate.

Fourth, the results from the suicide analysis (Chapter Seven) are particularly relevant to the recently published national strategy for the prevention of suicide, *Choose Life* (The Scottish Executive 2002b). The Choose Life report was criticised in Chapter Seven for the exclusion of deprived areas as a geographically defined priority group. This criticism was supported through the identification of a social gradient of suicide; the fact that Glasgow reported significantly higher suicide rates than the Highlands, Other Cities and All Other Areas; because suicide among younger adults was shown to cluster in and around central Glasgow; and because the Poisson modelling of demonstrated that suicide risk was higher in Glasgow when the area type was controlled for.

In conclusion, the suicide analyses conducted in this thesis suggest that suicide prevention strategies, such as *Choose Life* (The Scottish Executive 2002b), should target deprived areas, in addition to geographically isolated areas. The finding that suicide among younger females in the Highlands and Islands was not significantly different to Glasgow or other parts of Scotland suggested that the factors other than social conditions derived from census questions are needed to guide policy for the reduction of suicide among females.

8.4. Limitations of the Study

While this study has demonstrated the benefits of creating consistent geographical areas for analysis of mortality data, inevitably, there were some limitations to this study. First, the limitations of conducting analyses under an ecological framework, as was the case in this study, must be considered. Most importantly, is that the patterns of mortality inequalities reported in this study refer to areas and cannot be inferred to the individuals that live within these areas. Nonetheless, the results of this study could be used to complement studies of health inequalities conducted using qualitative methods, and/or smaller scale quantitative methods.

Second, while the merging strategy used to construct the CATTs was more effective than using population estimation techniques, there were a number of factors that impeded their design, such as the absence of a geographically correct boundary file of 1981 Enumeration Districts for Scotland. However, the 1991 OAs were typically divisions of the 1981 EDs and it was therefore possible to approximate the 1981 EDs from the 1991 boundary file.

The generation of CATTs used for the analysis in this study, and those recommended for most other studies (CATT2), were created by treating all polygons that contained two or less residential buildings from ADDRESS-POINT™ as erroneous or 'sliver' polygons, which were subsequently merged with adjacent zones. This meant that up to two houses from a census unit might be incorrectly assigned to a particular CATT2. Nevertheless, an error of two households was much more accurate than the displacement of one postcode unit, which contained an average of 16 households. Furthermore, the CATT2 boundaries retained the main urban and rural settlements across Scotland, which were lost in the CATT0 and CATT1 generations of CATTs.

Third, in this study the deprivation index first developed by Carstairs and Morris (1991) has been used to explore the social gradient of mortality, and has elucidated the extent to which inequalities widened over time. The Carstairs index of deprivation was used in this study because it was originally designed for Postcode Sectors and Health Boards in Scotland using data from the 1981 census. However, the Index has been criticised for its inclusion of car ownership as a marker of deprivation, because residents in rural areas are more likely to require a vehicle out of necessity rather than as a marker of wealth. More detailed deprivation indices are available, such as the Area Deprivation Index constructed by Kearns *et al.* (2000) or the Scottish Index of Multiple Deprivation (The Scottish Executive 2004), but these indices rely upon data derived from sources other than the census, and were not available for the entire study period. Therefore, in spite of these criticisms of the Carstairs index of deprivation, it was considered to be the most appropriate representation of social circumstances for this thesis.

8.5. Opportunities for Future Research

While conducting this research, a number of interesting research avenues were identified, but were not explored. This section discusses a number of potential research questions that would maximise the potential value inherent in the mortality dataset and the CATTs. First, this research has demonstrated the versatility of the CATTs with respect to the analysis of mortality between 1981 and 2001. However, there are many other social contexts that could benefit from CATT-based analysis. Any social or health data that have been recorded at the postcode level can be aggregated to the CATT2 level, which could be used to identify locations that are more susceptible to infectious diseases than others; or to conduct an ecological study of trends in cancer incidence and mortality over time.

Second, the mortality data used in this study have not been fully exploited. Each record in the mortality dataset included the marital status, occupation and social class of the deceased in addition to the age, sex and cause of death. It is well known that the occupation and social class information included on a death certificate is unreliable (Carstairs and Morris 1991), but the marital status information might highlight differences in mortality inequalities. One possible research avenue is to examine the risk of suicide by marital status, to determine whether suicide risk is less common among married individuals but more common among divorced individuals.

This study has examined mortality differentials for eight broad causes of death, although the mortality dataset contained a more specific cause of death. Further research should investigate inequalities in mortality from particular cancers, such as breast cancer among females and prostate cancer among males. Given the associations between smoking and lung cancer, and drinking and liver cirrhosis, the changing pattern of inequalities from these causes of death also warrant further investigation. The detailed causes of death could also be used to examine inequalities by method used for completing suicide.

Third, as the CATTs are consistent through time, each zone can be analysed using a longitudinal, or panel framework. Indeed, a panel-based negative binomial model was used to estimate suicide risk in Chapter Seven, but was not shown to be significantly better than a standard pooled cross-sectional model. However, further research is required to examine the versatility of the CATTs for longitudinal analysis. For example, a panel model would enable the change in mortality to be estimated in relation to societal changes over time.

Fourth, the changing pattern of mortality in Scotland could be used to identify geographic winners and losers: areas in which mortality reduced (winners) or increased (losers) over time. Observing the changing rank position of CATTs in terms of mortality rates over time could distinguish winners from losers.

Fifth, Chapter Six demonstrated that there was a strong association between population change and most causes of death. However, while most areas that suffered population decline had the highest mortality, it is possible that declining areas could have relatively low levels of mortality. Conversely, areas of population growth could also have higher than average death rates. These areas could be identified and examined using a combination of quantitative and qualitative methods to determine the social conditions that make them resilient to change. The results of such a study could be used to inform policy makers of measures that are required to modify health behaviours that would lead to a better quality of life.

8.6. Key Findings (in Summary)

For the creation of Consistent Areas Through Time (CATTs) (Chapter Four):

- The merging strategy used in this study was more accurate than population estimation approaches.
- Postcode units efficiently linked 1981 and 1991 census areas to create SUPER EDs, but inadequately represented 2001 OAs.
- Household level data from ADDRESS-POINT™ were required to integrate the 2001 census with the SUPER EDs.

Inequalities were examined using three approaches (Chapter Five):

- *Period specific* – in which 1981 SMRs were based on 1981 deprivation quintiles, and 2001 SMRs were based on 2001 quintiles.

- *Consistent quintiles* – in which 2001 deprivation quintiles, and 1981 death rates, were used to calculate SMRs for 1981 and 2001.

- *Social mobility groups* – in which CATTs were categorised according to the way in which their deprivation profiles changed over time.

- The results showed that using consistent quintiles were only marginally different to those obtained for period specific quintiles.

Relative inequalities across all ages:

- Increased for males and the total population, but reduced for females for all cause mortality.

- Reduced for stroke mortality among males, and for stroke, accidents, and cancer for females.

- Widened most for suicide among males and were wider still among females.

- Were generally higher for males than females.

Relative inequalities for premature deaths (<65 years):

- Widened for males and females for each cause of death studied.

- Widened least for cancer and widened most for heart disease among males and females.

- Ranged from 1.92 for cancer among females to 5.46 among males.

The relationship between population change (1981-2001) and mortality (1999-2001) (Chapter Six):

- Was affected by geographic scale, in which the strength of the association generally strengthened as the size of the zones increases.

- Areas of population decline exhibited higher mortality ratios than stable areas or areas of population growth.

- However, when deprivation in declining, stable and growing areas was controlled for, declining areas failed to have higher mortality. Rather, areas of population growth had higher mortality rates in the most deprived quintile for the total population and for males.

With regard to suicide in Scotland (Chapter Seven):

- Between 1981 and 2001, suicide increased among younger adults (15-44) but reduced among older adults (45+), although relative inequalities in both age groups widened over time.

- Glasgow has higher rates of suicide than the Highlands, but this relationship was negated once deprivation was controlled for.

- Suicides exhibited spatial clustering in and around Glasgow for younger males and younger females (separately and combined) in 1981, 1991, 2001 and 1981-2001.

- Individual CATTs were used to model suicide risk. The first model found that suicide in Glasgow was significantly higher than the Highlands, for males and females, when the geographic area was controlled for. However, when adjustments were made for social conditions, Highlands had higher rates than Glasgow for males, but not for females.

Recommendations to Policy Makers:

- The CATTs should be considered as a key higher geography in the design of the 2011 census boundaries.

- A broad-spectrum approach to reducing health inequalities is required.

- Resource allocation processes should consider the area-based deprivation rather than the total population in areas.

- Greater Glasgow should be considered as a priority area in the reduction of suicide in Scotland.

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